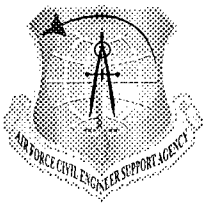


AFCESA/CES Technical Report 01-10
Tyndall AFB, FL 32403-5319

Risk Based Reliability Centered Maintenance of DOD Fire Protection Systems

January 1999

Kenneth Dugan
Risk Technologies LLC
Knoxville, TN

John Farquharson
JBF Associates, Inc
Knoxville, TN

Fred Walker
Air Force Civil Engineer Support Agency
Tyndall AFB, FL

Joseph Gott
Naval Facilities Engineering Command
Washington DC

Robert DiAngelo
US Army Corps of Engineers
Washington, DC

Kevin King
US Marine Corps
Washington, DC

Navin Mehta
Defense Logistic Agency
Washington, DC

Notice Page

Risk Technologies LLC, Knoxville, TN and JBL Associates Inc., Knoxville, TN prepared this report under contract F0863797C6022 for the U. S. Air Force, Air Force Civil Engineer Support Agency, Technical Support Directorate, Mechanical/Electrical/Fire Division. The work was review and revised by the Department of Defense Committee on Fire Protection Engineering. The work was used as the basis for the Uniform Facility Criteria 3-600-02, *Maintenance of Fire Protection Systems,* 1 January 2001.

The work was funded by the U. S. Air Force, Air Force Civil Engineer Support Agency, Technical Support Directorate, Mechanical/Electrical/Fire Division. The authors thank the many field reviewers without whom this work and the UFC 3-600-02 would never have been completed.

The contents of this report are not to be used for advertising or promotional purposes. Citation of brand names does not constitute an official endorsement or approval of this work by any manufacturer. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

HQ AFCESA/CES technical editors did not edit this report.

Department of Defense personnel and contractors may order reports through the Defense Technical Information Center:

DTIC-BR SUITE 0944
8725 JOHN J KINGMAN RD
FT BELVIOR VA 22060-6218
Telephone: (800) 225-3842
E-mail help@dtic.mil
msorders@dtic.mil
WWW http://www.dtic.mil/

All others may order reports through the National Technical Information Service:

NTIS
5285 PORT ROYAL RD
SPRINGFIELD VA 22161
Telephone (703) 487-4650
(703) 487=4639
E-mail orders@ntis.fedworld.gov
WWW http://www.ntis.gov/index.htm/

For a listing of all AFCESA technical reports:

AFRL/MLQ/TIL
ATTN: MR ANDREW D POULIS
139 BARNES DRIVE – SUITE 2
TYNDALL AFB FL 32403-5323

For information on all aspects of the Air Force Civil Engineer Support Agency, visit our World Wide Web site: http://www.afcesa.af.mil/.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 1999	Final

4. TITLE AND SUBTITLE
Risked Based Reliability Centered Maintenance of DOD Fire Protection Systems

5. FUNDING NUMBERS
Contract No.
F0863797C6022

6. AUTHOR(S)
K. Dugan*, J. Farquharson**, F. Walker, J. Gott, R. DiAngelo, K. King, N. Mehta

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Risk Technologies, LLC
9050 Executive Park Drive, Suite 102B
Knoxville, TN 37923

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Civil Engineer Support Agency
139 Barnes Drive - Suite 1
Tyndall AFB, FL 32403-5319

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AFCESA/CES-TR-01-10

11. SUPPLEMENTARY NOTES
* Risk Technologies, LLC, Knoxville, TN
**JBF Associates, Inc., Knoxville, TN

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release, distribution in unlimited

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*

The report documents a risk based reliability centered evaluation of tasks associated with the inspection, test and maintenance of fire protection systems. The report demonstrated it is possible to achieve a 99% reliability of system performance on demand of fire with fewer tasks than recommended by current national consensus prescriptive standards.

14. SUBJECT TERMS
Fire protection, Fire sprinkler, Fire detection, System maintenance, Building maintenance, Reliability, Reliability-centered maintenance

15. NUMBER OF PAGES
214

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

ABSTRACT

This report was produced to determine the feasibility of using a reliability centered maintenance approach for the maintenance of engineered fire protection features in Department of Defense (DOD) facilities. Concerns for property, equipment, and personnel were among the comprehensive considerations included in this report to ensure safety of human life, continuity of mission, and to minimize injuries and damage to property and equipment. The reports concludes a risked based reliability centered maintenance approach is possible and provides recommended minimum inspection test and maintenance frequencies necessary to ensure a 99% reliability of activation/function on demand.

FOREWORD

This report has been developed from an evaluation of facilities at DOD establishments, from surveys of maintenance methods, and from selection of the best practices of the Naval Facilities Engineering Command (NAVFACENGCOM), Army Corps of Engineers, Air Force Office of the Civil Engineer, Deputy Chief of Staff for Installations and Logistics Headquarters Marine Corps, other Government agencies, and the private sector. This report handbook is based on recognized reliability centered maintenance concepts and reliability centered risk management. This report was prepared using, to the maximum extent feasible, model building codes, National Fire Codes, industrial standards, and other recognized standards. This report employed accepted risk measure to evaluate the potential failure modes for each different fire suppression and detection system.

The report concluded many prescriptive maintenance requirements found in consensus-based codes did not contribute to the ability of a specific system to respond to a fire event. The Department of Defense Committee on Fire Protection Engineering, U.S. Army, HQ USACE/CEMP-E; U.S. Navy, NAVFACENGCOM HQ Code 150; U.S. Marine Corps, HQMC Code LFF-1; U.S. Air Force, HQ AFCESA/CES; Defense Logistics Agency (DLA), HQ DLA-D through DLSC-BIS; Defense Mapping Agency (DMA), HQ DMA (HRH); and all other DOD components, DUSD (IA&I) Industrial Affairs & Installations will be using this data to develop DOD guidance for the maintenance, test and inspection of fire protection features.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

The Air Force and other Service have experience a continuing decrease in reliability of fire protection systems over the past five to ten years. The prescriptive national consensus codes have increasing the number of maintenance tasks and increasing the frequency of execution for these task. At the same time Air Force and the other services have been facing cuts in their real property maintenance budgets and reduction in the number of craftspersons authorized to execute these requirements. All the services reported to varying degrees maintenance not being accomplished for various reasons including; insufficient craftspersons, too many requirements, no prioritization or importance assigned prescriptive requirements.

The national consensus prescriptive requirements for system maintenance are not based on the unique conditions, which exist on DOD installations. In DOD the service controls all elements of the system, the building, the user, the maintainer, and the AHJ are all within DOD where in the private sector each of these elements may be a separate independent identity.

1.2 APPROACH

Headquarters Air Force Civil Engineer Support Agency (AFCESA) funded this effort to develop reliability-centered maintenance requirements for installed fire detection and suppression systems. Using accepted risked based procedures the contractor, RiskTek identified those maintenance actions, which contribute to the systems ability to respond to a fire event. The effort applied performance based reliability centered maintenance methodology to identify the minimum required inspection, test and maintenance tasks necessary to achieve a 99% overall system reliability to respond to an actual fire event. This manual considers the unique conditions existing on DOD installation where the service/agency has complete control of the facility and occupants.

2. RCM ANALYSIS APPROACH

2.1 RCM ANALYSIS

The following RCM analysis approach was used to develop an optimized set of ITM tasks for installed fire protection systems. RCM analysis is a systematic process for optimizing maintenance requirements for engineered systems. The output of an RCM analysis is a list of maintenance tasks to prevent or detect failures of equipment that are critical to system function.

2.2 RCM ANALYSIS STEPS

The RCM analysis of each fire protection system included the following five steps:

Step 1 — System selection and system boundary definition

Step 2 — System functions and functional failures definition

Step 3 — Failure mode and effect analysis (FMEA)

Step 4 — Failure mode risk characterization

Step 5 — Task selection and frequency assessment

The following sections describe each step.

2.2.1 System Selection and System Boundary Definition

A detailed component list was developed for a typical installation for each type of fire protection system. The information in Air Force manual AFM 91-73, *Maintenance of Fire Protection Systems*, was used to develop the component lists. The boundaries for a system were defined, and then the associated boundary interfaces (i.e., inputs, outputs) were identified. Tables 2.1 through 2.12 provide lists of components that were analyzed for each fire protection system.

Table 2.1 Fire Detection and Alarm System Components

Power supply devices • Dedicated AC power supply • Secondary power supply • Control panel power supply • Control panel batteries	Detectors for initiating device circuit (IDC) and signal line circuit (SLC) • Smoke detector • Heat detector • Flame detector • Gas detector	Notification appliances • Horn • Strobe • Bell • Synchronizing module
Hardwired control panel devices • Processor board • Notification appliance board • Initiating device board • Remote annunciator board and annunciator • Central interface • City box tie-in	Manually activated alarm devices • City box • Manual pull station • Intelligent manual pull station	Voice notification systems • Voice notification module • Microphone • Amplifiers • Automatic message generator • Speakers
Intelligent/analog system control panel devices • Microprocessor board • Notification appliance board • Signaling line circuit board • LCD/alphanumeric display • DACT or central station interface	Fire suppression system waterflow devices • Waterflow switch • Pressure switch • Intelligent input modules for waterflow and pressure switches	Miscellaneous equipment • Intelligent interface modules for IDCs • Intelligent interface modules for equipment operational status • Remote panel • Solenoid supervision and releasing equipment from a notification appliance circuit
Radio transmitter system control panel devices • Microprocessor board • Transmitter	Fire safety equipment and suppression system release devices • Fire safety equipment control remote relays • Deluge/pre-action release module • Releasing module board • Intelligent output interface module	

Table 2.2 Water Supply System Components

Storage tanks • Gravity feed • Suction • Pressure supply	Fire pumps • Centrifugal fire pump • Jockey pump • Diesel engine driver • Electric motor driver • Pump driver controller	Water supply piping and valves • Pump suction piping and valves • Pump discharge piping and valves • Circulation relief valve • Fire pump relief valve
Storage tank auxiliary systems • Heating • Water makeup	Fire pump auxiliary systems • Electric power supply system • Fuel supply system • Pump house heating system • Pump house ventilation system	Fire hydrants • Fire hydrant supply line • Fire hydrant valve • Fire hydrant barrel • Fire hydrant drain • Fire hydrant connection valve

Table 2.3 Water-based System Components

Firewater supply	Fire department connection (FDC)
Backflow preventer	Inspector test connection
Post-indicating valve (PIV)	Sprinkler heads • Fusible link • Glass bulb
Main control valve	Sprinkler piping • Piping • Piping supports

Table 2.4 Wet Pipe Sprinkler System Components

Wet pipe alarm check valve	Main drain valve
Retard chamber	Strainer
Water motor gong	Bypass line

Table 2.5 Dry Pipe Sprinkler System Components

Dry pipe valves • Differential and low differential valve • Mechanical (latched-clapper) valve	Priming water system • Priming water chamber • Priming water level test valve • Priming water drain • Priming water piping and valve
Quick opening devices • Accelerator • Exhauster	Piping and valves • Alarm circuit • Test valve and piping • Drain valve and piping
Air supply system	Retard chamber

Table 2.6 Deluge, Water Spray, and Pre-action System Components

Deluge, water spray, and pre-action valve	Deluge and water spray nozzles
Valve release devices • Weighted release mechanism • Diaphragm release mechanism • Mercury check release mechanism • Release solenoid • Manual pull station	Piping and valves • Alarm circuit • Drain valve and piping
Air supply system	

Table 2.7 Water Mist System Components

Water mist cylinders • Atomizing gas • Water supply	Supply piping and tubing
Water mist nozzles • Impingement • Pressure jet • Twin fluid	Potable water supply • Supply pump • Supply pump pressure relief valve • Supply strainer

Table 2.8 Foam and Foam-water System Components

Proportioner	Standard balance proportioner devices • Foam concentrate pump • Foam concentrate pump pressure relief valve • Concentrate pressure sensing line • Water pressure sensing line • Automatic balancing valve
Piping • Water supply piping • Foam concentrate supply piping • Proportioner discharge piping • Concentrate storage tank fill piping • Concentrate recycle piping • Ball drip valves	In-line balanced proportioner devices • Foam concentrate pump • Foam concentrate pump pressure relief valve • Water pressure sensing line • Diaphragm balancing valve • Pressure regulating valve
Foam concentrate storage tanks • Bladder tank • Atmospheric tank • Pressure vessel	Foam discharge devices • Monitor • Low expansion foam maker • High expansion aspirator type foam generator • High expansion blower type foam generator
Control valves • Actuated • Nonactuated	

Table 2.9 Standpipe and Hose System Components

Hose	Hose storage device
Hose valve outlets	Hose valve
Pressure regulating valve	Piping
Hose nozzle	

Table 2.10 Wet and Dry Chemical System Components

Piping	Fusible links
Nozzles	Actuation device
Cylinders • Dry chemical pressurized storage cylinder • Nonpressurized extinguishing agent cylinder • Expellant gas cylinder	

Table 2.11 Halon and Halon Alternative System Components

Extinguishing agent cylinder	Discharge piping
Nozzles	Cylinder release valve

Table 2.12 Carbon Dioxide System Components

High pressure carbon dioxide system • High pressure cylinder • Control head	Low pressure carbon dioxide storage system • Storage tank • Storage system relief devices • Refrigeration system • Discharge control valve • Supervisory electro-manual pilot cabinet (SEMPC)
Discharge piping	Nozzles

Tables 2.13 through 2.24 provide the system boundaries for each fire protection system. Each table contains three columns: **Interface Type**, **Bounding System/Component**, and **Interface Location**. The **Interface Type** column identifies if the transfer of materials, energy, or signals crossing the boundary are ingoing or outgoing. For example, electric power to the devices within a system will be identified as "In," and the flow of water out of the sprinkler head will be identified as "Out." The **Bounding System/Component** column identifies the system or component within the boundary that receives or transfers out materials, energy, or signals. For example, the fire detection and alarm AC power system is identified as a bounding system because it receives AC power from a source outside of the boundary (e.g., the base power distribution system). The **Interface Location** column identifies the location where the FMEA of the fire protection system began or stopped. For example, for the fire detection and alarm system AC power, the FMEA began at the connection to the base AC power distribution system.

Table 2.13 Fire Detection and Alarm System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fire detection and alarm system AC power	Connection of dedicated supply to the base AC power distribution system
In	Heat, smoke, and radiant energy initiating devices	Initiating device inlet
In	Suppression system waterflow devices	Sensing element
In	Manually activated alarm initiating devices	Access to the initiating device
In	Voice communicated alarm equipment	Microphone or message generator
Out	Audible and visual notification devices	Various notification appliances, communication output devices (e.g., speakers, radio transmitter), and alarm panels
Out	Fire safety equipment release devices	Release module board or relays
Out	Fire suppression system release devices	Release modules

Table 2.14 Water Supply System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Storage tank heating system	Heating system utility connection
In	Storage tank water makeup system	Makeup water isolation valve
In	Electric power supply	Incoming power transmission substation
In	Fuel supply system	Fuel storage tank
In	Pump driver controller	Suppression system waterflow switch
In	Fire hydrant water supply line	Fire hydrant isolation valve
Out	Discharge piping	Suppression system control valve
Out	Storage tank overflow lines	Overflow line outlet
Out	Storage tank vents	Vent outlet
Out	Storage tank instruments	Instrument readouts

Table 2.15 Water-based System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	FDC	FDC inlet
In	Sprinkler piping	Suppression system bulk main and/or cross main connection
In/Out	Firewater supply	Fire system supply system connection and suppression system control valve
Out	Sprinkler heads	Sprinkler head nozzle
Out	ITC	ITC outlet

Table 2.16 Wet Pipe Sprinkler System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fire water supply	Wet pipe system control valve
Out	Sprinkler piping	Wet pipe system bulk main and/or cross main connection
Out	Main drain valve and piping	Main drain outlet
Out	Water motor gong	Water motor gong

Table 2.17 Dry Pipe Sprinkler System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fire water supply	Dry pipe system control valve
In	Air supply system	Air supply system compressor
In	Priming water	Priming water valve
Out	Sprinkler piping	Dry pipe system bulk main and/or cross main connection
Out	Test valve and piping	Test outlet
Out	Drain valve and piping	Drain outlet

Table 2.18 Deluge, Water Spray, and Pre-action System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fire water supply	Suppression system control valve
In	Air supply system	Air supply system compressor
Out	Deluge and water spray nozzles	Nozzle outlet
Out	Drain valve and piping	Drain outlet

Table 2.19 Water Mist System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Potable water supply pump	Pump motor starter
In	Potable water supply pump	Start signal to the pump motor starter
In	Potable water supply	Potable water supply pump suction
Out	Water mist nozzle	Nozzle outlet

Table 2.20 Foam and Foam-water System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fire water supply	Foam/foam-water system control valve
In	Foam concentrate pump	Pump motor starter
In	Foam concentrate pump	Start signal to the pump motor starter
In	Foam concentrate storage tank fill piping	Storage tank fill pipe inlet
In	High expansion blower type foam generator	Blower electric power source
In	Foam discharge devices	Air inlet
Out	Foam concentrate storage tanks	Vent outlet
Out	Foam concentrate storage tanks	Drain outlet
Out	Ball drip valve	Ball drip valve outlet
Out	Foam discharge devices	Foam outlet

Table 2.21 Standpipe and Hose System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fire water supply	Standpipe connection to fire water supply
Out	Hose valve outlet	Hose valve outlet
Out	Hose nozzle	Hose nozzle outlet

Table 2.22 Wet and Dry Chemical System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Fusible link	Fusible link
Out	Nozzles	Nozzle outlets

Table 2.23 Halon and Halon Alternative System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	Cylinder release valve	Cylinder release valve electric power source
In	Cylinder release valve	Cylinder release valve actuation signal
Out	Nozzles	Nozzle outlets

Table 2.24 Carbon Dioxide System Boundaries

Interface Type	Bounding System/Component	Interface Location
In	High pressure carbon dioxide control head	Control head release solenoid actuation signal
In	Low pressure carbon dioxide storage tank	Storage tank liquid fill inlet
In	Low pressure carbon dioxide refrigeration system	Refrigeration compressor electric power source
In	Low pressure carbon dioxide SEMPC	Electrically actuated solenoid electric power source
Out	Low pressure carbon dioxide storage system relief devices	Relief device discharge
Out	Nozzles	Nozzle outlet

2.2.2 System Functions and Functional Failures Definition

In general, the system functions considered for the fire protection systems were suppression of a fire, actuation of fire safety devices (e.g., smoke dampers, fire doors), and/or notification of occupants and/or fire responders. Functional failures of interest (i.e., system effects that the ITM tasks are to prevent or detect) were identified for each system function. In addition, system degradation levels were qualitatively defined for functional failures (for use in Step 4).

Tables 2.25 through 2.36 contain a description of the fire protection system functions, functional failures, and system degradation level definitions. Functional failures have been divided into primary and secondary functional failures. Primary functional failures are the potential failures that can result in a system failure that prevents the fire protection system from completing its primary design intent (i.e., protect human lives and/or property). Secondary functional failures are the other potential system failures that can occur.

Table 2.25 Fire Detection and Alarm System Functions and Functional Failures

System Functions: Detect the presence of, or the potential for, fire. Notify occupants to evacuate and notify fire responders of a fire or a potential fire. In addition, actuate fire suppression systems and fire safety functions (e.g., release fire doors, control fans for smoke management)	
Primary Functional Failures: • Loss of notification to occupants • Loss of notification to fire responders • Failure to actuate fire suppression systems • Failure to actuate fire safety functions	
Secondary Functional Failures: • Loss of local indication • Failure to indicate trouble conditions and/or operating status • False notification of a fire or trouble condition • False trip of fire detection and suppression systems, and fire safety functions • Delayed notification of occupants and/or fire responders • Delayed actuation of fire suppression systems and/or fire safety functions	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Loss of the ability to: 1. Notify occupants and fire responders, and 2. Actuate fire suppression system and fire safety functions
Partial	Loss of the ability to: 1. Notify occupants or fire responders, or 2. Actuate fire suppression systems or fire safety functions Failure of a single system or device when there are redundant systems or multiple devices that perform the same primary function (i.e., total system degradation does not occur because of the redundancy available)
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.26 Water Supply System Functions and Functional Failures

System Functions: Supply an adequate flow of water (and water pressure) to the fire suppression system(s) (those that use water) so that the suppression systems can perform as designed. In addition, store a sufficient inventory of water to allow fire suppression system(s) to operate for the designed time
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate inventory of water (in a storage tank) • Loss of fire suppression capabilities due to inadequate flow of water (from a storage tank, fire pump, or fire hydrant) • Loss of fire suppression capabilities due to inadequate discharge pressure (from a fire water pump)
Secondary Functional Failures: • Damage to wood tanks or protective paint in steel tanks • Discharge of water through the main discharge relief valve (on a fire pump) • Failure to prevent accumulation of carbon monoxide, potentially resulting in overexposure to personnel
System Degradation Definitions:

System Degradation Level	Range of Effects
Total	Complete loss of fire suppression capabilities due to: 1. Inadequate (no or low) inventory of water preventing the fire suppression system from operating, 2. Inadequate (no or low) flow of water preventing the fire suppression system from operating, or 3. Inadequate (no or low) discharge pressure preventing the fire suppression system from operating
Partial	Significant reduction of fire suppression capabilities due to: 1. Inadequate (less than design) inventory of water reducing the time that the fire suppression system can operate, 2. Inadequate (less than design) flow of water reducing the effectiveness of the fire suppression system, or 3. Inadequate (less than design) discharge pressure reducing the effectiveness of the fire suppression system
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.27 Water-based System Functions and Functional Failures

System Functions: Supply an adequate flow of water and water pressure to fire suppression system(s) (those that use water) so that the suppression systems can perform as designed, including proper flow rate and pressure to individual devices (i.e., sprinkler heads, foam-water proportioners). In addition, provide a sufficient flow rate of water to actuate waterflow devices (to notify occupants and fire responders).	
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate supply (i.e., flow rate or pressure) of water • Loss of remote and local notification	
Secondary Functional Failures: • False trip of remote and local notification devices	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to inadequate (no or low) supply of water preventing the fire suppression system from operating
Partial	Significant reduction of fire suppression capabilities due to inadequate (less than design) supply of water, reducing the effectiveness of the fire suppression system Failure of a single system or device when there are redundant systems or multiple devices that perform the same primary function (i.e., total system degradation does not occur because of the redundancy available)
Minimal	Loss of function or failure that results in a secondary functional failure Reduction of fire suppression capabilities due to inadequate supply of water because the fire department connection (FDC) is not functioning properly

Table 2.28 Wet Pipe System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying an adequate flow of water and coverage onto the fire. In addition, actuate waterflow devices (to notify occupants and fire responders)	
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate supply (i.e., flow rate or pressure) of water • Loss of remote and/or local notification	
Secondary Functional Failures: • False trip of remote and local notification devices	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to inadequate (no or low) supply of water onto the fire
Partial	Significant reduction of fire suppression capabilities due to inadequate (less than design) supply of water onto the fire Loss of remote and/or local notification capabilities
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.29 Dry Pipe System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying an adequate flow of water and coverage onto the fire. In addition, actuate waterflow devices (to notify occupants and fire responders). Also, ensure piping downstream of the dry pipe valve remains free of water	
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate supply (i.e., flow rate or pressure) of water • Loss of remote and/or local notification	
Secondary Functional Failures: • Premature opening of the dry pipe valve • False trip of remote and local notification devices	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to inadequate (no or low) supply of water onto the fire
Partial	Significant reduction of fire suppression capabilities due to inadequate (less than design) supply of water onto the fire Loss of remote and/or local notification capabilities
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.30 Deluge, Water Spray, and Pre-action System Functions and Functional Failures

System Functions: Control the spreading of a fire and extinguish a fire or operate a foam-water system by supplying an adequate flow of water and coverage onto the fire. In addition, actuate waterflow devices (to notify occupants and fire responders). Also, ensure piping downstream of the deluge or pre-action valve remains free of water	
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate supply (i.e., flow rate or pressure) of water • Loss of remote and/or local notification	
Secondary Functional Failures: • False trip of the fire system valve (i.e., deluge or pre-action valve) • False trip of remote and local notification devices	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to inadequate (no or low) supply of water onto the fire
Partial	Reduction of fire suppression capabilities due to inadequate (less than design) supply of water onto the fire Loss of remote and/or local notification capabilities
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.31 Water Mist System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying a specific quantity of water in the form of mist onto the fire	
Primary Functional Failures: • Loss of fire suppression capabilities due to improper water droplet size • Loss of fire suppression capabilities due to inadequate supply (i.e., flow and total quantity) of water • Loss of fire suppression capabilities due to improper coverage	
Secondary Functional Failures: • Premature discharge of water (i.e., false trip of the system)	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to: 1. Improper water droplet size from all nozzles due to lack of aspiration, 2. Inadequate (no or low flow or no or low quantity) supply of water onto the fire, or 3. Improper coverage (i.e., misdirected or missing nozzles) onto the fire
Partial	Significant reduction of fire suppression capabilities due to: 1. Improper water droplet size from one nozzle due to lack of aspiration, 2. Inadequate (less than design flow or quantity) supply of water onto the fire, or 3. Improper coverage (i.e., misdirected or missing nozzles) from one nozzle
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.32 Foam and Foam-water System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying an adequate flow of water and foam-water solution (with proper concentration of foam concentrate) onto the fire

Primary Functional Failures:

- Loss of fire suppression capabilities due to inadequate flow of water
- Loss of fire suppression capabilities due to improper concentration of foam concentrate in the foam-water solution
- Loss of fire suppression capabilities due to inadequate inventory of foam concentrate
- Loss of fire suppression capabilities due to improper aspiration of foam-water solution

Secondary Functional Failures:

- None identified

System Degradation Definitions:

System Degradation Level	Range of Effects
Total	Complete loss of fire suppression capabilities due to: 1. Inadequate (no or low) flow of water to or from the foam-water proportioner, 2. Improper (too low or high) concentration of foam concentrate in the foam-water solution, 3. Inadequate (no or low) inventory of foam concentrate in the foam concentrate storage tank, or 4. Improper (no or little) aspiration of foam-water solution
Partial	Significant reduction of fire suppression capabilities due to: 1. Inadequate (less than design) flow of water to or from the foam-water proportioner, 2. Improper (slightly outside of the acceptable concentration limits) concentration of foam concentrate in the foam-water solution, 3. Inadequate (less than the design amount) inventory of foam concentrate in the foam concentrate storage tank, or 4. Improper (not optimum) aspiration of foam-water solution
Minimal	Minor reduction of fire suppression capabilities due to: 1. Inadequate (less than design) flow of water to or from the foam-water proportioner, 2. Improper (outside of the acceptable concentration) concentration of foam concentrate in the foam-water solution, 3. Inadequate (less than the design amount) inventory of foam concentrate in the foam concentrate storage tank, or 4. Improper (not optimum) aspiration of foam-water solution Operational difficulties: 1. Loss of ability to detect a leak if the bladder is leaking (bladder storage tank only) 2. Inability to recharge foam concentrate (to the storage tank)

Table 2.33 Standpipe and Hose System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying water to hoses for use by fire responders	
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate flow of water • Loss of fire suppression capabilities due to improper coverage (i.e., improper spray pattern from a hose nozzle)	
Secondary Functional Failures: • None	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to inadequate (no or low) flow of water to all hoses or hose connections
Partial	Significant reduction of fire suppression capabilities due to: 1. Inadequate (less than design) flow of water on all hoses or hose connections, or 2. Inadequate (no or low) flow of water to a single hose or hose connection
Minimal	Reduction in fire suppression capabilities to a given point due to improper coverage (i.e., improper spray pattern from a hose nozzle)

Table 2.34 Wet and Dry Chemical System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by (1) supplying a specific quantity and/or sufficient flow of wet or dry chemical extinguishing agent to a specific point (i.e., local application) or (2) achieving a concentration of dry or wet chemical extinguishing agent in an area (i.e., flooding application)

Primary Functional Failures:

- Loss of fire suppression capabilities due to inadequate quantity of wet/dry chemical (local application only)
- Loss of fire suppression capabilities due to inadequate flow of wet/dry chemical (local application)
- Loss of fire suppression capabilities due to inadequate concentration of dry chemical (flooding application)

Secondary Functional Failures:

- Premature discharge of wet/dry chemical (i.e., false trip of the system)

System Degradation Definitions:

System Degradation Level	Range of Effects
Total	Complete loss of fire suppression capabilities due to: 1. Inadequate (no or small) quantity of wet or dry chemical delivered to a specific point, 2. Inadequate (no or low) flow of wet or dry chemical discharged to a specific point, or 3. Inadequate (no or low) concentration of dry chemical in the area being flooded (i.e., no chemical discharged or discharged so slow that concentration does not build up)
Partial	Significant reduction of fire suppression capabilities due to: 1. Inadequate (less than design amount) quantity of wet or dry chemical delivered to a specific point, 2. Inadequate (less than design) flow of wet or dry chemical delivered to a specific point, 3. Inadequate (no or small) quantity of wet or dry chemical delivered through one nozzle (when there are multiple nozzles) or one piping branch, 4. Inadequate (no or low) flow of wet or dry chemical discharged through one nozzle (when there are multiple nozzles) or one piping branch, or 5. Inadequate (significant concentration but less than design) concentration of dry chemical in the area to be flooded
Minimal	Minor reduction of fire suppression capabilities due inadequate (slightly less than design) concentration of dry chemical (e.g., blocking of one nozzle when there are multiple nozzles in the area being flooded) Loss of function or failure that results in a secondary functional failure

Table 2.35 Halon and Halon Alternative System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying a specific quantity of halon (or halon alternative) extinguishing agent needed to maintain a desired concentration for a specific time period (i.e., soak time).	
Primary Functional Failures: • Loss of fire suppression capabilities due to failure to supply sufficient quantity of suppression agent (i.e., halon or halon alternative)	
Secondary Functional Failures: • False trip of the valve	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to the failure to supply a sufficient quantity of the suppression agent to achieve the required concentration
Partial	Significant reduction of fire suppression capabilities due to the failure to supply a sufficient quantity of the suppression agent needed to maintain the concentration for the soak time Significant reduction of fire suppression capabilities due to the failure to supply the extinguishing agent through all the nozzles (e.g., blockage of a single nozzle when there are multiple nozzles)
Minimal	Loss of function or failure that results in a secondary functional failure

Table 2.36 Carbon Dioxide System Functions and Functional Failures

System Functions: Control the spreading of a fire and/or extinguish a fire by supplying a specific quantity of carbon dioxide needed to maintain a specific concentration for a specified time (i.e., soak time) to a specific point (i.e., local application) or to an area (i.e., flooding application)	
Primary Functional Failures: • Loss of fire suppression capabilities due to inadequate quantity of suppression agent (i.e., carbon dioxide) • Loss of fire suppression capabilities due to inadequate flow of wet/dry chemical (local application) • Loss of fire suppression capabilities due to inadequate concentration of dry chemical (flooding application)	
Secondary Functional Failures: • False trip and release of carbon dioxide	
System Degradation Definitions:	
System Degradation Level	**Range of Effects**
Total	Complete loss of fire suppression capabilities due to: 1. Inadequate (no or low) quantity of carbon dioxide delivered to a specific point, or 2. Inadequate quantity of carbon dioxide needed to achieve desired concentration of carbon dioxide
Partial	Significant reduction of fire suppression capabilities due to: 1. Inadequate (less than design amount) quantity of carbon dioxide delivered to a specific point or area, or 2. Inadequate quantity of carbon dioxide needed to maintain concentration for the soak time
Minimal	Loss of function or failure that results in a secondary functional failure Loss of single nozzle in a flooding application Operational difficulties: 1. Inability to recharge carbon dioxide to the storage tank 2. Loss of ability to detect when the storage tank is full when recharging 3. Failure to close the discharge control valve

2.2.3 Failure Mode and Effect Analysis (FMEA)

An FMEA was performed to systematically identify component failures resulting in functional failures of interest. The key elements of the FMEA are defined by the following terms:

- Failure modes — conceivable malfunctions that prevent the component from performing its intended function
- System effects — anticipated effects (i.e., functional failures) that a specific component failure mode will have on the operation of the system

- Causes — credible reasons why failure modes might occur

The failure modes for a component were derived from standard listings of failure modes by component type (e.g., pump, valve, transmitter). The team modified and added failure modes, as necessary, to ensure all conceivable malfunctions for a component were included in the analysis. During the FMEA meetings, the team (1) decided whether each failure mode resulted in a system effect that caused a functional failure of interest and (2) determined whether a credible cause existed for failure modes of interest (i.e., those that resulted in functional failures of interest).

The results of the FMEAs of the fire protection systems are summarized in the FMEA tables in the Appendix to Volume 2 of this handbook.

2.2.4 Failure Mode Risk Characterization

The risk characterization was performed for each component failure mode resulting in a functional failure of interest as part of the FMEA. The risk characterizations are used to assess the significance of each failure mode of interest. The risk was characterized by qualitatively ranking (1) the probability of failure on demand (PFOD) for the component failure mode and (2) the resultant system degradation level.

The PFOD ranking is the estimate of the likelihood of the component failing in that particular mode. The qualitative PFOD rankings for component failure modes were high, medium, low, and very low. Table 2.37 provides the qualitative PFOD rankings and the corresponding PFOD estimates used. The RCM team used (1) fire data from the Air Force manual AFM 91-73, *Maintenance of Fire Protection Systems*, (2) generic equipment failure data, and (3) the fire protection engineers' experience to estimate the PFOD ranking for each component failure mode (that resulted in a functional failure).

Table 2.37 Correlation of Qualitative PFOD Rankings to PFOD Estimates

PFOD Ranking	PFOD Estimate
High	$> 10^{-2}$
Medium	$>10^{-3}$ to 10^{-2}
Low	$>10^{-4}$ to 10^{-3}
Very Low	$< 10^{-4}$

The system degradation levels are the estimates of the severity level of the functional failure that results from a component failure mode (i.e., a measure of the functional failure's consequence). The qualitative system degradation levels were total, partial, and minimal. The range of effects for each system degradation level was defined for each functional failure during Step 2 (see Tables 2.25 through 2.36). Table 2.38 describes the general range of effects for the three levels of system degradation.

Table 2.38 General Range of Effects for System Degradation Levels

System Degradation Level	Range of Effects
Total	Complete loss of primary system functions
Partial	Impairment of a primary system function, loss of a redundant component critical to the operation of a primary system function, or total loss of a secondary system function
Minimal	Impairment of a secondary system function, loss of a redundant component critical to the operation of a secondary system function, delayed response of primary or secondary system function, or false trip of the system

The system degradation and PFOD rankings were used in the task selection and frequency assessment step (Step 5 of the RCM process) to identify component failure modes that require ITM tasks and to determine the appropriate frequency for ITM tasks.

2.2.5 Task Selection and Frequency Assessment

The ITM task selection process involved identifying all the applicable tasks in the various National Fire Protection Association (NFPA) codes for each component failure mode of interest. The applicability of a task was determined by ascertaining if the task would be an effective means of preventing or detecting the failure mode and its associated causes.

The frequency assessment was performed using a mathematical model. This model uses the PFOD ranking and the NFPA recommended test intervals to estimate the failure rate for a component failure mode. The model also incorporates the frequency of fire occurring, an estimate of the ITM task effectiveness in correcting the failure mode, and overall system (and ultimately the component) performance requirements. The assumed values used in the model for fire frequency and task effectiveness are 1/50 years and 99%, respectively. Appendix B explains (1) the model derivation and (2) the development of the recommended frequency tables for ITM tasks.

The model resulted in three tables that contain the recommended frequencies for ITM tasks. Table 2.39 provides the recommended frequencies for component failure modes resulting in total system degradation. Tables 2.40 and 2.41 provide the recommended frequencies for component failure modes resulting in partial system degradation and minimal system degradation, respectively. The cells in the table (defined by the intersection of a PFOD ranking and NFPA recommended test interval) contain the recommended frequency for an ITM task.

Table 2.39 Recommended Frequencies for Component Failure Modes Resulting in Total System Degradation

PFOD Ranking	NFPA Recommended Test Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
High	< 1 week	1 week	1 month	1 month	1 month
Medium	1 month	1 month	6 months	6 months	6 months
Low	6 months	6 months	1 to 2 years	1 to 2 years	1 to 2 years
Very Low	1 to 2 years	1 to 2 years	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required

Table 2.40 Recommended Frequencies for Component Failure Modes Resulting in Partial System Degradation

PFOD Ranking	NFPA Recommended Test Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
High	1 week	1 month	6 months	6 months	6 months
Medium	6 months	6 months	1 to 2 years	1 to 2 years	1 to 2 years
Low	1 to 2 years	1 to 2 years	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required
Very Low	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required

Table 2.41 Recommended Frequencies for Component Failure Modes Resulting in Minimal System Degradation

PFOD Ranking	NFPA Recommended Test Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
High	1 month	6 months	1 to 2 years	1 to 2 years	1 to 2 years
Medium	1 to 2 years	1 to 2 years	1 to 2 years	Inspection and testing not required	Inspection and testing not required
Low	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required
Very Low	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required

For situations in which there are redundant components, the targeted availability for the component can be reduced while still maintaining the overall system availability. For example,

an overall system availability of 0.99 can be maintained by installing redundant components with component availabilities of 0.99 (versus 0.999 for nonredundant components). Table 2.42 provides the frequencies for ITM tasks for redundant components with failure modes resulting in total system degradation.

Table 2.42 Recommended Frequencies for Redundant Components with Failure Modes Resulting in Total System Degradation

PFOD Ranking	NFPA Recommended Test Interval				
	Weekly	Monthly	Quarterly	Semi-annually	Annually
High	1 week	1 month	6 months	6 months	6 months
Medium	6 months	6 months	1 to 2 years	1 to 2 years	1 to 2 years
Low	1 to 2 years	1 to 2 years	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required
Very Low	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required	Inspection and testing not required

For situations in which a component (e.g., fire pump) services 10 or more systems, the frequencies (in the above tables) are increased to account for the increased frequency of a fire (i.e., 10 facilities with a frequency of fires of 1/50 years results in frequency of 1/5 years for a common component). Table 2.43 provides the increased frequencies for common components.

Table 2.43 Increased Frequencies for Common Components Servicing 10 or More Systems

Recommended Frequency for a Component Servicing Less than 10 Systems	Increased Frequency for a Common Component Servicing 10 or More Systems
< 1 week	< 1 week
1 week	1 week
1 month	2 weeks
6 months	3 months
1 to 2 years	1 year
Inspection and testing not required	Inspection and testing not required

The worksheets in Appendix A provide the results of the task selection and frequency assessment step.

3. ITM GUIDES

3.1 ITM GUIDE DESCRIPTION

The ITM guide for each system contains three columns: **ITM Task**, **NFPA Code Reference**, and **Task Frequency**. Below is a description of the information in each column:

- **ITM Task** — This column lists the task to be performed and describes the primary and secondary purposes for the tasks (i.e., the primary failure mode[s] that the task is attempting to prevent or detect, and any additional [secondary] failure modes that can be prevented or detected).

- **NFPA Code Reference** — This column identifies the National Fire Protection Association (NFPA) code and section number for the ITM task.

- **Task Frequency** — This column provides the recommended frequency from the frequency assessment performed during the RCM analysis.

3.2 ITM TASK DESCRIPTIONS AND GUIDES

3.2.1 The ITM tasks outlined in Tables 2.2.2 through 2.2.18 were selected to assure the fire protection would function when called upon. In general, ITM tasks consist of one of the following categories:

- **Prevention-directed** – tasks performed on specified intervals to prevent or retard failures (e.g., replacing seals in a fire-water pump)
- **Condition-directed** – nonintrusive tasks performed with the system "on-line" to detect the onset of a failure or failure symptom (e.g., performing vibration monitoring on a firewater pump)
- **Fault-directed** – tasks performed on specified intervals to discover a hidden failure before the demand is required (e.g., periodically starting a diesel-driven backup firewater pump)
- **Event-directed** – tasks performed upon specific events (i.e., during each repair or installation) to prevent future failure (e.g., balancing the impeller during pump repair)

A trend to supervise components increases the likelihood that conditions or faults will be detected without an inspection activity. In these cases, the ITM task is to respond to the alarm "as necessary" and to test the supervisory device (e.g., valve tamper switch) periodically. The frequencies reflected in the tables below credit the improved fault or condition monitoring by reducing the required inspection frequency.

Some tests should be event driven. For example, a main drain test is intended to verify the open condition of a control valve to a sprinkler or water spray system. This test need only be done when the control valve has been operated for maintenance or testing. The frequency indicated in the tables is "not required" except after valve operation.

Some of the tasks called out by NFPA are identified as "not required" in the tables. These are tasks which either do not improve the operability of the systems because of the faults they detect are not significant impairments, the faults are detected by other tasks or means, or the faults will be self-evident (fix it when it breaks) without significant impairment to the system.

Table 3.2.2 Fire Detection and Alarm Systems

ITM Task	NFPA Reference	Task Frequency
Alarm device test to verify: • Proper device operation.	NFPA 25, Section 2-3.3	Not required
Control equipment visual inspection to ensure: • There are no changes that may affect equipment performance.	NFPA 72, Section 7-3.1[1-2]	Annually
Control equipment test to ensure: • Proper receipt of alarm.	NFPA 72, Section 7-3.2[1-2a]	Annually
Lamps/LED's inspection to ensure: • All proper bulbs are illuminated and LED's are displayed	NFPA 72, Section 7-3.2[1-2d]	Annually
Primary power to ensure: • Primary power is sufficient to carry load in the absence of secondary power.	NFPA 72, Section 7-3.2[1-2e]	Annually
Fire alarm box visual inspection to verify: • Device is accessible and free of physical obstructions.	NFPA 72, Section 7-3.1[9e]	Annually
Visual heat detector inspection to verify: • There are no changes that may affect equipment performance.	NFPA 72, Section 7-3.1[9f]	1 to 2 years
Visual flame detector inspection to verify: • There are no changes that may affect equipment performance.	NFPA 72, Section 7-3.1[9g]	Annually
Visual gas detector inspection to verify: • There are no changes that may affect equipment performance.	NFPA 72, Section 7-3.1[9g]	Annually
Visual smoke detector inspection to verify: • There are no changes that may affect equipment performance.	NFPA 72, Section 7-3.1[9h]	1 to 2 years

Emergency communications equipment test to ensure: • Proper equipment operation.	NFPA 72, Section 7-3.2[11]	1 to 2 years
Annunciator test to verify: • Proper operation.	NFPA 72, Section 7-3.2[13]	Annually
Initiating device test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[14]	Annually
Special hazard actuation switch operation • Proper device operation.	NFPA 72, Section 7-3.2[14c]	1 to 2 years
Heat detector functional test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[14e]	1 to 2 years
Fire alarm box test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[14f]	Not required (supervised) Annually (unsupervised)
Flame detector functional test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[14g]	Annually
Gas detector functional test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[14g]	Annually
Smoke detector functional test to verify: • Proper device operation	NFPA 72, Section 7-3.2[14h]	1 to 2 years
Interface equipment test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[16]	Not required
Special hazard equipment test to verify: • Proper device operation.	NFPA 72, Section 7-3.2[16c]	Not required
Notification appliance test to verify: • Proper appliance operation.	NFPA 72, Section 7-3.2[18]	Annually
Notification appliance audibility test to ensure: • Proper audibility levels.	NFPA 72, Section 7-3.2[18a]	1 to 2 years
Notification appliance clarity test to ensure: • Proper message clarity.	NFPA 72, Section 7-3.2[18b]	1 to 2 years
Notification appliance visibility test to ensure: • Proper visibility levels.	NFPA 72, Section 7-3.2[18c]	1 to 2 years
Digital alarm radio transmitter (DART) test to verify: • Proper operation.	NFPA 72, Section 7-3.2[20a]	Annually

Digital alarm communicator transmitter (DACT) test to verify: • Proper operation.	NFPA 72, Section 7-3.2[20b]	Not required
Smoke detector sensitivity test to ensure: • Proper detector actuation during fire scenarios.	NFPA 72, Section 7-3.2.1	Not required
Response to supervisory alarm	N/A	As necessary

Table 3.2.3 Wet Pipe Sprinkler Systems

ITM Task	NFPA Reference	Task Frequency
Floor level sprinkler inspection for: • Corrosion; • Foreign materials; • Paint; • Physical damage; • Correct installation; and • Obstructions.	NFPA 25, Section 2-2.1.1	Not required
Spare sprinkler inspection for: • Proper number and type of sprinklers; and • Applicable sprinkler wrenches	NFPA 25, Section 2-2.1.3	Not required
Floor level piping/fitting inspection for: • Mechanical damage; • Leakage; • Corrosion; • Misalignment; and • Bearing loads.	NFPA 25, Section 2-2.2	Not required
Floor level hanger/brace inspection for: • Mechanical damage.	NFPA 25, Section 2-2.3	Not required
Wet pipe system gauge inspection for: • Good condition; and • Normal supply pressure.	NFPA 25, Sections 2-2.4.1 & 9-4.3.1.1	Not required
Building inspection for: • Areas of possible freezing	NFPA 25, Section 2-2.5	Not required
Waterflow alarm device inspection for: • Physical damage.	NFPA 25, Section 2-2.6	1 to 2 years
Hydraulic nameplate inspection for: • Presence and legibility	NFPA 25, Section 2-2.7	Not required
Standard sprinkler head sampling test for: • Improper response characteristics	NFPA 25, Section 2-3.1.1	50 years
Fast response sprinkler head sampling test for: • Improper response characteristics	NFPA 25, Section 2-3.1.1 Exception No. 2	20 years, then 10 year thereafter
Extra high temperature sprinkler head sampling test for: • Improper response characteristics due to solder migration	NFPA 25, Section 2-3.1.1 Exception No. 3	5 years

Gauge replacement/test for: • Accuracy and calibration.	NFPA 25, Section 2-3.2	Not required
Waterflow alarm device test for: • Proper operation; • Receipt of alarm; and • Proper valve operation.	NFPA 25, Sections 2-3.3 & 9-2.7	1 to 2 years
Antifreeze solution test for: • Correct mixture	NFPA 25, Section 2-3.4	Annually or after system trip
Main drain test for: • Water quality; and • Supply piping valve closure and obstructions.	NFPA 25, Section 9-2.6	Not required (After valve operation)
Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 9-3.3.1	Monthly/Annually*
Valve operation test for: • Proper operability.	NFPA 25, Section 9-3.4.2	1 to 2 years
Valve stem lubrication to: • Prevent stem rusting.	NFPA 25, Section 9-3.5	1 to 2 years
Alarm valve external inspection for: • Normal pressure indication from the gauges; • Physical damage; • Correct control valve positioning; and • Leakage.	NFPA 25, Section 9-4.1.1	Annually
Alarm valve internal inspection for: • Proper physical condition; and • Blockage or degradation.	NFPA 25, Section 9-4.1.2	5 years
Alarm valve internal cleaning to: • Maintain proper valve condition.	NFPA 25, Section 9-4.1.3	Not required
Fire department connection (FDC) inspection for: • Accessibility; • Physical damage; and • Leakage.	NFPA 25, Section 9-7.1	Not required
Internal FDC inspection for: • Physical obstructions.	NFPA 25, Section 9-7.2	As necessary
Supervisory alarm response	N/A	As necessary
Waterflow alarm response	N/A	As necessary

*Unsupervised/supervised

Table 3.2.4 Dry Pipe Sprinkler Systems

ITM Task	NFPA Reference	Task Frequency
Floor level sprinkler inspection for: • Corrosion; • Foreign materials; • Paint; • Physical damage; • Correct installation; and • Obstructions.	NFPA 25, Section 2-2.1.1	Not required
System gauge inspection to ensure: • Gauge condition; and • Normal supply pressures	NFPA 25, Sections 2-2.4.2 & 9-4.4.1.2	Not required
Spare sprinkler inspection for: • Proper number and type of sprinklers; and • Applicable sprinkler wrenches	NFPA 25, Section 2-2.1.3	Not required
Floor level piping/fitting inspection for: • Mechanical damage; • Leakage; • Corrosion; • Misalignment; and • Bearing loads.	NFPA 25, Section 2-2.2	Not required
Floor level hanger/brace inspection for: • Mechanical damage.	NFPA 25, Section 2-2.3	Not required
Hydraulic nameplate inspection for: • Presence and legibility	NFPA 25, Section 2-2.7	Not required
Standard sprinkler head sampling test for: • Improper response characteristics	NFPA 25, Section 2-3.1.1	50 years
Fast response sprinkler head sampling test for: • Improper response characteristics	NFPA 25, Section 2-3.1.1 Exception No. 2	20 years, then 10 year thereafter
Extra high temperature sprinkler head sampling test for: • Improper response characteristics due to solder migration	NFPA 25, Section 2-3.1.1 Exception No. 3	5 years
Gauge replacement/test for: • Accuracy and calibration.	NFPA 25, Section 2-3.2	Not required
Air drier maintenance to ensure: • Proper operation.	NFPA 25, Section 2-4.2.1	Manufacturer's recommendation

Air compressor maintenance to ensure: • Proper operation.	NFPA 25, Section 2-4.2.2	Manufacturer's recommendation
Main drain test for: • Water quality; and • Supply piping valve closure and obstructions.	NFPA 25, Section 9-2.6	Not required (After valve operation)
Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 9-3.3.1	Monthly/Annually*
Valve operation test for: • Proper operability.	NFPA 25, Section 9-3.4.2	1 to 2 years
Valve stem lubrication to: • Prevent stem rusting.	NFPA 25, Section 9-3.5	1 to 2 years
Valve enclosure heating equipment inspection to ensure: • Minimum valve enclosure temperature.	NFPA 25, Section 9-4.4.1.1	1 to 2 years
Low temperature alarm test to ensure: Proper operation.	NFPA 25, Sections 9-4.4.1.1, Ex. #2 & 9-4.4.2.7	Annually at the beginning of the heating season
External dry pipe valve inspection for: • Physical damage; • Proper control valve positioning; and • Leakage.	NFPA 25, Section 9-4.4.1.3	1 to 2 years
Internal dry pipe valve inspection for: • Physical condition.	NFPA 25, Section 9-4.4.1.4	See "Dry Pipe Trip Test" frequency
Strainer, filter and restricting orifice inspection for: • Pluggage; • Fouling; and • Corrosion.	NFPA 25, Section 9-4.4.1.5	5 years
Priming water level test for: • Proper priming water level.	NFPA 25, Section 9-4.4.2.1	1 to 2 years
Dry pipe trip test for: • Proper valve operation.	NFPA 25, Section 9-4.4.2.2	1 to 2 years**
Quick opening device test for: • Proper operation	NFPA 25, Section 9-4.4.2.4	Not required
Low air pressure alarm test for: • Proper operation	NFPA 25, Section 9-4.4.2.6	1 to 2 years

Automatic air pressure maintenance device test for: • Proper operation	NFPA 25, Section 9-4.4.2.8	1 to 2 years
Repair any system leaks to: • Prevent spurious operation	NFPA 25, Section 9-4.4.3.1	As necessary
Dry pipe valve interior cleaning to: • Prevent valve fouling and failure.	NFPA 25, Section 9-4.4.3.2	See "Dry Pipe Trip Test" frequency
Low point drainage to: • Prevent system freezing.	NFPA 25, Section 9-4.4.3.3	After actuation and before onset of freezing conditions
Fire department connection (FDC) inspection for: • Accessibility; • Physical damage; and • Leakage.	NFPA 25, Section 9-7.1	Not required
Internal FDC inspection for: • Physical obstructions.	NFPA 25, Section 9-7.2	As necessary
Low air pressure response	N/A	As necessary
Low temperature alarm response	N/A	As necessary
Supervisory alarm response	N/A	As necessary
Waterflow alarm response	N/A	As necessary

*Unsupervised/supervised

** Every 3 years, the trip test should be performed with the system control valve fully open. In all other years, the trip test should be performed with the system control valve partially open.

Table 3.2.5 Deluge Systems

ITM Task	NFPA Reference	Task Frequency
Floor level sprinkler inspection for: • Corrosion; • Foreign materials; • Paint; • Physical damage; • Correct installation; and • Obstructions.	NFPA 25, Section 2-2.1.1	Not required
Floor level piping/fitting inspection for: • Mechanical damage; • Leakage; • Corrosion; • Misalignment; and • Bearing loads.	NFPA 25, Section 2-2.2	Not required
Floor level hanger/brace inspection for: • Mechanical damage.	NFPA 25, Section 2-2.3	Not required
System gauge inspection to ensure: • Gauge condition; and • Normal supply pressures.	NFPA 25, Sections 2-2.4.2 & 9-4.3.1.1	Not required
Building inspection for: • Areas of possible freezing	NFPA 25, Section 2-2.5	Not required
Hydraulic nameplate inspection for: • Presence and legibility	NFPA 25, Section 2-2.7	Not required
Spare sprinkler inspection for: • Proper number and type of sprinklers; and • Applicable sprinkler wrenches	NFPA 25, Section 2-2.1.3	Not required
Gauge replacement/test for: • Accuracy and calibration.	NFPA 25, Section 2-3.2	Not required
Strainer ITM for: • Plugging; • Fouling; and • Corrosion.	NFPA 25, Section 4-2.2.3	1 to 2 years
Main drain test for: • Water quality; and • Supply piping valve closure and obstructions.	NFPA 25, Section 9-2.6	Not required (After valve operation)

Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 9-3.3.1	Monthly/Annually*
Valve operation test for: • Proper operability.	NFPA 25, Section 9-3.4.2	1 to 2 years
Valve stem lubrication to: • Prevent stem rusting.	NFPA 25, Section 9-3.5	1 to 2 years
Valve enclosure heating equipment inspection to ensure: • Minimum valve enclosure temperature.	NFPA 25, Section 9-4.3.1	1 to 2 years
Low temperature alarm test for: • Proper operation.	NFPA 25, Sec. 9-4.3.1.1, Ex. #2 & Sec. 9-4.3.2.11	Annually at the beginning of the heating season
External valve inspection for: • Physical damage; • Proper control valve positioning; • Leakage; and • In service electrical components.	NFPA 25, Section 9-4.3.1.2	1 to 2 years
Internal valve inspection for: • Physical condition	NFPA 25, Section 9-4.3.1.3	See "Full System Trip Test" frequency/5 years**
Strainer, filter, restricting orifice and diaphragm chamber inspection for: • Plugging; • Fouling; and • Corrosion.	NFPA 25, Section 9-4.3.1.4	5 years
Priming water level test for: • Proper priming water level.	NFPA 25, Section 9-4.3.2.1	1 to 2 years
Full system trip test to ensure: • Proper valve operation; • Proper discharge patterns; and • Proper discharge pressures.	NFPA 25, Section 9-4.3.2.2	1 to 2 years
Full flow test discharge observations to: • Show pipe plugging has not occurred; and • Demonstrate proper coverage.	NFPA 25, Section 9-4.3.2.3	Not required
Manual actuation operation to ensure: • Proper manual actuation operation.	NFPA 25, Section 9-4.3.2.6	Not required
System valve interior cleaning to: • Prevent valve fouling and failure.	NFPA 25, Section 9-4.3.3.2	See "Full System Trip Test" frequency

Low point drainage to: • Prevent system freezing.	NFPA 25, Section 9-4.3.3.3	After actuation and before onset of freezing conditions
Fire department connection (FDC) inspection for: • Accessibility; • Physical damage; and • Leakage.	NFPA 25, Section 9-7.1	Not required
Internal FDC inspection for: • Physical obstructions.	NFPA 25, Section 9-7.2	As necessary
Low temperature alarm response	N/A	As necessary
Supervisory alarm response	N/A	As necessary
Waterflow alarm response	N/A	As necessary

*Unsupervised/supervised
** Self-resetting valve interiors shall be inspected every five years.

Table 3.2.6 Pre-action Systems

ITM Task	NFPA Reference	Task Frequency
Floor level sprinkler inspection for: • Corrosion; • Foreign materials; • Paint; • Physical damage; • Correct installation; and • Obstructions.	NFPA 25, Section 2-2.1.1	Not required
Floor level piping/fitting inspection for: • Mechanical damage; • Leakage; • Corrosion; • Misalignment; and • Bearing loads.	NFPA 25, Section 2-2.2	Not required
Floor level hanger/brace inspection for: • Mechanical damage.	NFPA 25, Section 2-2.3	Not required
System gauge inspection to ensure: • Gauge condition; and • Normal supply pressures.	NFPA 25, Sections 2-2.4.2 & 9-4.3.1.1	Not required
Building inspection for: • Areas of possible freezing	NFPA 25, Section 2-2.5	Not required
Hydraulic nameplate inspection for: • Presence and legibility	NFPA 25, Section 2-2.7	Not required
Standard sprinkler head sampling test for: • Improper response characteristics	NFPA 25, Section 2-3.1.1	50 years
Fast response sprinkler head sampling test for: • Improper response characteristics	NFPA 25, Section 2-3.1.1 Exception No. 2	20 years, then 10 year thereafter
Extra high temperature sprinkler head sampling test for: • Improper response characteristics due to solder migration	NFPA 25, Section 2-3.1.1 Exception No. 3	5 years
Spare sprinkler inspection for: • Proper number and type of sprinklers; and • Applicable sprinkler wrenches	NFPA 25, Section 2-2.1.3	Not required
Gauge replacement/test for: • Accuracy and calibration.	NFPA 25, Section 2-3.2	Not required

Strainer ITM for: • Plugging; • Fouling; and • Corrosion.	NFPA 25, Section 4-2.2.3	1 to 2 years
Main drain test for: • Water quality; and • Supply piping valve closure and obstructions.	NFPA 25, Section 9-2.6	Not required (After valve operation)
Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 9-3.3.1	Monthly/Annually*
Valve operation test for: • Proper operability.	NFPA 25, Section 9-3.4.2	1 to 2 years
Valve stem lubrication to: • Prevent stem rusting.	NFPA 25, Section 9-3.5	1 to 2 years
Valve enclosure heating equipment inspection to ensure: • Minimum valve enclosure temperature.	NFPA 25, Section 9-4.3.1	1 to 2 years
Low temperature alarm test for: • Proper operation.	NFPA 25, Sec. 9-4.3.1.1, Ex. #2 & Sec. 9-4.3.2.11	Annually at the beginning of the heating season
External valve inspection for: • Physical damage; • Proper control valve positioning; • Leakage; and • In service electrical components.	NFPA 25, Section 9-4.3.1.2	1 to 2 years
Internal valve inspection for: • Physical condition	NFPA 25, Section 9-4.3.1.3	See "Full System Trip Test" frequency/5 years**
Strainer, filter, restricting orifice and diaphragm chamber inspection for: • Plugging; • Fouling; and • Corrosion.	NFPA 25, Section 9-4.3.1.4	5 years
Priming water level test for: • Proper priming water level.	NFPA 25, Section 9-4.3.2.1	1 to 2 years
Full system trip test to ensure: • Proper valve operation; • Proper discharge patterns; and • Proper discharge pressures.	NFPA 25, Section 9-4.3.2.2	1 to 2 years

Pre-action system full flow test discharge observations to: • Show pipe plugging has not occurred; and • Demonstrate proper coverage.	NFPA 25, Section 9-4.3.2.3	Not required
Manual actuation operation to ensure: • Proper manual actuation operation.	NFPA 25, Section 9-4.3.2.6	Not required
Low air pressure alarm test for: • Proper operation	NFPA 25, Section 9-4.3.2.10	Not required
Automatic air pressure maintenance device test for: • Proper operation	NFPA 25, Section 9-4.3.2.12	Not required
Repair any system leaks to: • Prevent spurious operation	NFPA 25, Section 9-4.3.3.1	As necessary
System valve interior cleaning to: • Prevent valve fouling and failure.	NFPA 25, Section 9-4.3.3.2	See "Full System Trip Test" frequency
Low point drainage to: • Prevent system freezing.	NFPA 25, Section 9-4.3.3.3	After actuation and before onset of freezing conditions
Fire department connection (FDC) inspection for: • Accessibility; • Physical damage; and • Leakage.	NFPA 25, Section 9-7.1	Not required
Internal FDC inspection for: • Physical obstructions.	NFPA 25, Section 9-7.2	As necessary
Low air pressure response	N/A	As necessary
Low temperature alarm response	N/A	As necessary
Supervisory alarm response	N/A	As necessary
Waterflow alarm response	N/A	As necessary

*Unsupervised/supervised

** Self-resetting valve interiors shall be inspected every five years.

Table 3.2.7 Water Spray Systems

ITM Task	NFPA Reference	Task Frequency
Floor level sprinkler inspection for: • Corrosion; • Foreign materials; • Paint; • Physical damage; • Correct installation; and • Obstructions.	NFPA 25, Section 2-2.1.1	Not required
Floor level piping/fitting inspection for: • Mechanical damage; • Leakage; • Corrosion; • Misalignment; and • Bearing loads.	NFPA 25, Section 2-2.2	Not required
Floor level hanger/brace inspection for: • Mechanical damage.	NFPA 25, Section 2-2.3	Not required
System gauge inspection to ensure: • Gauge condition; and • Normal supply pressures.	NFPA 25, Sections 2-2.4.2 & 9-4.3.1.1	Not required
Building inspection for: • Areas of possible freezing	NFPA 25, Section 2-2.5	Not required
Hydraulic nameplate inspection for: • Presence and legibility	NFPA 25, Section 2-2.7	Not required
Spare sprinkler inspection for: • Proper number and type of sprinklers; and • Applicable sprinkler wrenches	NFPA 25, Section 2-2.1.3	Not required
Gauge replacement/test for: • Accuracy and calibration.	NFPA 25, Section 2-3.2	Not required
Strainer ITM for: • Plugging; • Fouling; and • Corrosion.	NFPA 25, Section 4-2.2.3	1 to 2 years
Main drain test for: • Water quality; and • Supply piping valve closure and obstructions.	NFPA 25, Section 9-2.6	Not required (After valve operation)

Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 9-3.3.1	Monthly/Annually*
Valve operation test for: • Proper operability.	NFPA 25, Section 9-3.4.2	1 to 2 years
Valve stem lubrication to: • Prevent stem rusting.	NFPA 25, Section 9-3.5	1 to 2 years
Valve enclosure heating equipment inspection to ensure: • Minimum valve enclosure temperature.	NFPA 25, Section 9-4.3.1	1 to 2 years
Low temperature alarm test for: • Proper operation.	NFPA 25, Sec. 9-4.3.1.1, Ex. #2 & Sec. 9-4.3.2.11	Annually at the beginning of the heating season
External valve inspection for: • Physical damage; • Proper control valve positioning; • Leakage; and • In service electrical components.	NFPA 25, Section 9-4.3.1.2	1 to 2 years
Internal valve inspection for: • Physical condition	NFPA 25, Section 9-4.3.1.3	See "Full System Trip Test" frequency/5 years**
Strainer, filter, restricting orifice and diaphragm chamber inspection for: • Plugging; • Fouling; and • Corrosion.	NFPA 25, Section 9-4.3.1.4	5 years
Priming water level test for: • Proper priming water level.	NFPA 25, Section 9-4.3.2.1	1 to 2 years
Full system trip test to ensure: • Proper valve operation; • Proper discharge patterns; and • Proper discharge pressures.	NFPA 25, Section 9-4.3.2.2	1 to 2 years
Full flow system test discharge observations to: • Show pipe plugging has not occurred; and • Demonstrate proper coverage.	NFPA 25, Section 9-4.3.2.3	Not required
Manual actuation operation to ensure: • Proper manual actuation operation.	NFPA 25, Section 9-4.3.2.6	Not required
System valve interior cleaning to: • Prevent valve fouling and failure.	NFPA 25, Section 9-4.3.3.2	See "Full System Trip Test" frequency

Low point drainage to: • Prevent system freezing.	NFPA 25, Section 9-4.3.3.3	After actuation and before onset of freezing conditions
Fire department connection (FDC) inspection for: • Accessibility; • Physical damage; and • Leakage.	NFPA 25, Section 9-7.1	Not required
Internal FDC inspection for: • Physical obstructions.	NFPA 25, Section 9-7.2	As necessary
Low temperature alarm response	N/A	As necessary
Supervisory alarm response	N/A	As necessary
Waterflow alarm response	N/A	As necessary

*Unsupervised/supervised
** Self-resetting valve interiors shall be inspected every five years.

Table 3.2.8 Water Mist Systems

ITM Task	NFPA Reference	Task Frequency
Water tank inspection to determine if: • Tank water level meets design requirements.	NFPA 750, Table 10-2(a)	Weekly/Annually*
Air receiver inspection to determine if: • System air pressure is adequate.	NFPA 750, Table 10-2(a)	Weekly/Annually*
Air compressor inspection to determine if: • System air pressure is adequate.	NFPA 750, Table 10-2(a)	Weekly/Annually*
Air pressure cylinders inspection to: • Confirm cylinders have correct pressure; and • Ensure indicator disk is free of damage.	NFPA 750, Table 10-2(a)	Weekly/Annually*
System operating components inspection to: • Ensure all system components are free of mechanical damage; and • Confirm proper valve positioning.	NFPA 750, Table 10-2(a)	Semiannually
Waterflow alarm and supervisory device inspection for: • Mechanical damage.	NFPA 750, Table 10-2(a)	Annually
Initiating device and detector inspection for: • General device condition.	NFPA 750, Table 10-2(a)	Annually
Battery, control panel and interface equipment inspection for: • General condition.	NFPA 750, Table 10-2(a)	Annually
System strainer and filter inspection for: • General condition.	NFPA 750, Table 10-2(a)	1-2 years
Control equipment and fiber optic cable connection inspection for: • General condition.	NFPA 750, Table 10-2(a)	1-2 years
Piping, fittings, hangers, nozzles and flexible tubing inspection for: • General condition.	NFPA 750, Table 10-2(a)	1-2 years
Pump churn test to ensure: • Proper operation.	NFPA 750, Table 10-2(b)	Semiannually
Compressor operation to ensure: • Proper operation	NFPA 750, Table 10-2(b)	Semiannually

Control equipment test to ensure: • Proper operation	NFPA 750, Table 10-2(b)	Annually
Main drain test to ensure: • Main water supply is unobstructed.	NFPA 750, Table 10-2(b)	Not required (After valve operation)
Remote alarm annunciation to ensure: • Proper alarm operation.	NFPA 750, Table 10-2(b)	Annually
Pump flow test to: • Ensure pump provides proper output.	NFPA 750, Table 10-2(b)	Annually
Battery test to: • Proper charge.	NFPA 750, Table 10-2(b)	Annually
Pressure relief valve manual operation to ensure: • Proper operation.	NFPA 750, Table 10-2(b)	Annually
Water level switch test to ensure: • Proper operation.	NFPA 750, Table 10-2(b)	Annually
Detector test to ensure: • Proper operation.	NFPA 750, Table 10-2(b)	Annually
Manual and automatic releasing mechanism test to ensure: • Proper operation.	NFPA 750, Table 10-2(b)	Annually
Control unit/PLC test to ensure: • Proper operation.	NFPA 750, Table 10-2(b)	Annually
Section valve function test to ensure: • Operability.	NFPA 750, Table 10-2(b)	Annually
Water analysis to ensure: • Proper water quality.	NFPA 750, Table 10-2(b)	As required (when filling)
Pressure cylinders pressurization to ensure: • Proper cylinder pressurization.	NFPA 750, Table 10-2(b)	5 years
System flow test to ensure: • Proper system operability.	NFPA 750, Table 10-2(b)	Not required
Pressure cylinders hydrostatic test to ensure: • Cylinder structural integrity.	NFPA 750, Table 10-2(b)	5-12 years
Automatic nozzle sampling test to ensure: • Proper operability.	NFPA 750, Table 10-2(b)	Not required
Water tank draining and refilling to ensure: • Tank structural integrity.	NFPA 750, Table 10-3.2	5-12 years

System flushing to: • Ensure system is maintained unobstructed.	NFPA 750, Table 10-3.2	After system operation
Strainers and filter cleaning to: • Ensure all strainers and filters are maintained unobstructed.	NFPA 750, Table 10-3.2	After system operation

Table 3.2.9 Foam and Foam-Water Systems

ITM Task	NFPA Reference	Task Frequency
Thorough inspection and operational check to ensure: • Proper foam concentration; • Foam concentrate pump is flushed; • All equipment (proportioning and discharge) is free of physical damage and leakage; • All actuators, manual and automatic, function; • Strainers are clean; and • Proper drainage pitch is maintained.	NFPA 11, Section 7-1	1 to 2 years
Spot-check inspection of underground piping for: • Deterioration.	NFPA 11, Section 7-1.2	5 years
Foam concentrate inspection for: • Evidence of sludging, deterioration; and • Quantity.	NFPA 11, Section 7-2	Annually
Thoroughly inspected and checked for proper operation to ensure: • Full operating condition.	NFPA 11A, Section 1-13.1	1 to 2 years
Inspection to ensure: • All equipment are free of leaks and damage; • Correct concentrate pumps operation; • Proper manual valves positioning; • Central panel lights operation; • All panel disconnects are in "ON" position; • A normal water supply; • Normal batteries and foam level; • Fire alarms are tested and silence is in "NORMAL" position; and • All supervised functions are in the "NORMAL" position.	NFPA 11A, Section A-1-13.1.4	1 to 2 years
Discharge test to ensure: • Proper operation and discharge characteristics.	NFPA 11A, Section 1-13.1.2	As necessary
Strainers cleaned and inspected to ensure: • Proper operation.	NFPA 11A, Section 1-13.1.5	After each actuation

Foam system piping inspection for: • Physical damage; • Corrosion; and • Misalignment.	NFPA 25, Section 8-2.3	1 to 2 years
Foam system hanger and support inspection for: • Condition; • Secure attachment; and • Damaged or missing hangers.	NFPA 25, Section 8-2.4	1 to 2 years
Nozzle location and position inspection to ensure: • Correct orientation.	NFPA 25, Section 8-2.5	1 to 2 years
Sprinkler location and position to ensure: • Correct orientation.	NFPA 25, Section 8-2.5	1 to 2 years
Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 8-2.7	Monthly/Annually*
Foam concentrate strainer inspection to ensure: • Blow-down valve is closed and plugged.	NFPA 25, Section 8-2.9.2	Annually
Removal and inspection of strainer baskets/screens to ensure: • Clean filter media.	NFPA 25, Section 8-2.9.2	After each discharge
Discharge area drainage to ensure: • Area drains properly.	NFPA 25, Section 8-2.10	Not required
Proportioning system inspection for: • Physical damage; • Proper valve positioning; • Adequate volume of concentrate; and • Leakage.	NFPA 25, Section 8-2.11	Semiannually
Foam concentrate sampling to ensure: • Concentrate usability.	NFPA 25, Section 8-2.12	Manufacturer's recommendation
Full flow test to ensure: • Proper system operation; • Adequate system pressure; and • Adequate coverage.	NFPA 25, Section 8-3.3	1 to 2 years
Manual actuation device test to ensure: • Manual actuation operation.	NFPA 25, Section 8-3.5	1 to 2 years
Concentration testing to ensure: • Proportioning system provides correct concentration.	NFPA 25, Section 8-3.6	See "Full Flow Test" frequency.

Ball drip valve cleaning to ensure: • Ball drip does not become clogged.	NFPA 25, Section 8-4.1(a)	5 years
Foam concentrate pump operation to ensure: • Pump operation.	NFPA 25, Sections 8-4.4(a) & .5(a)	Semiannually
Balancing valve flushing to ensure: • Foam concentrate does not buildup up on diaphragm.	NFPA 25, Section 8-4.4(c)	5 years
Foam concentrate tank maintenance for: • Drain and flush; • Corrosion inspection; and • Hydrostatic test	NFPA 25, Sections 8-4.1(c) & .2(b)	10 years
Proper flushing after actuation	N/A	As necessary
Proper drainage after actuation	N/A	As necessary
Verification of proper refilling	N/A	As necessary

*Unsupervised/supervised

Table 3.2.10 Standpipe and Hose Systems

ITM Task	NFPA Reference	Task Frequency
Piping inspection for: • Piping damage; • Control valve damage; • Pipe support damage; and • Supervisory device damage.	NFPA 25, Section 3-2.1	1 to 2 years
Hose storage device inspection for: • Damage; • Proper hose storage; • Ease of use; and • Obstructions.	NFPA 25, Section 3-2.3	Not required
Hose storage cabinet inspection for; • Ease of use; • Damage; • Obstructions; and • Accessibility.	NFPA 25,, Section 3-2.3	Not required
Standpipe flow test to ensure: • Sufficient flow capacity.	NFPA 25, Section 3-3.1.1	5 years
Hydrostatic inspection to ensure: • Proper operation.	NFPA 25, Section 3-3.2.1	5 years
Alarm device test to ensure: • Proper operation	NFPA 25, Section 3-3.3	Not required
Hose connection/pressure reducing valve (PRV) inspection for: • Damage; • Leakage; • Obstructions; • Missing cap; and • Non-smooth valve operation.	NFPA 25, Sections 9-5.2.1 & .3.1	Semiannually
Hose connection/PRV flow test to ensure: • Proper operation.	NFPA 25, Sections 9-5.2.2 & .3.2	5 years
Hose test to ensure: • Suitability for continued use.	NFPA 1962, Section 2-3.2	5 years, then 3 years thereafter

Hose inspection for: • Debris; • Vandalization; • Physical damage; • Rotting; and • Mildew.	NFPA 1962, Section 2-3.3	Semiannually and/or after each use
Nozzle inspection for: • Debris; • Damage; • Proper shutoff valve operation; • Thread and gasket condition; and • Full operation of adjustments.	NFPA 1962, Section 4-1.2	1 to 2 years and/or after each use
Coupling inspection for: • Damaged threads; • Corrosion; • Internal gasket condition; and • General coupling condition.	NFPA 1962, Section 4-2.1	1 to 2 years and/or after each use

Table 3.2.11 Hydrants and Monitors

ITM Task	NFPA Reference	Task Frequency
Mainline strainer inspection and cleaning to ensure: • Strainer will not create flow blockage.	NFPA 25, Sections 4-2.2.3 & -4.2	1 to 2 years and after each flow
Dry/wet hydrant inspection for: • Accessibility; • Water or ice in the barrel (dry); • Improper drainage (dry); • Leaks, cracks or other damage; and • Worn threads.	NFPA 25, Section 4-2.2.4 & .5	1 to 2 years and after each flow
Monitor nozzle inspection for: • Physical damage.	NFPA 25,, Section 4-2.2.6	1 to 2 years
Hose house inspection for: • Accessibility; and • Physical damage.	NFPA 25, Section 4-2.2.7	1 to 2 years
Hydrant flow test to ensure: • Proper functioning; and • Proper drainage.	NFPA 25, Section 4-3.2	1 to 2 years
Monitor nozzle test to ensure: • Proper functioning; and • Full range of motion.	NFPA 25, Section 4-3.3	1 to 2 years
Hydrant lubrication to ensure: • Proper operating condition.	NFPA 25, Section 4-4.3.1	1 to 2 years
Provide adequate space to hydrant and provide protection to prevent: • Inaccessibility; and • Physical damage.	NFPA 25, Section 4-4.3.2	As necessary
Monitor nozzle lubrication to ensure: • Proper operating condition.	NFPA 25, Section 4-4.4	1 to 2 years
Hose house maintenance to ensure: • Proper operating conditions.	NFPA 25, Section 4-4.5	As necessary

Table 3.2.12 Fire Pumps

Pump system inspection includes observation of: • Pump house conditions (sufficient ventilation, adequate temperature); • Open pump control valves open; • Pressure gauges reading normal; • Piping leaks; • Electrical system conditions; • Diesel engine system conditions; and • Steam system conditions.	NFPA 25, Section 5-2.2	Semiannually
Pump churn test to: • Ensure automatic/manual operation upon demand; • Ensure continuous output; and • Detect pump assembly deficiencies not evident by inspection.	NFPA 25, Section 5-3.2.1 & .2	Semiannually
Pump flow test to: • Ensure pump provides proper output.	NFPA 25, Section 5-3.3.1	5 years
Battery check for: • Proper charge.	NFPA 25, Section 5-5.1	Semiannually
Calibrate pressure switch settings to: • Ensure proper pump operating range.	NFPA 25, Section 5-5.1	As necessary
Check coupling alignment to: • Ensure pump shaft is aligned within the pump.	NFPA 25, Section 5-5.1	1 to 2 years
Check pump shaft end play to: • Ensure pup shaft is aligned with driver.	NFPA 25, Section 5-5.1	1 to 2 years
Circuit breaker trip to: • Ensure full circuit breaker operation.	NFPA 25, Section 5-5.1	1 to 2 years
Circuit breaker switch operation to: • Ensure circuit breaker switch operability.	NFPA 25, Section 5-5.1	Annually
Connection inspection to: • Ensure all connections are made.	NFPA 25, Section 5-5.1	Not required
Emergency power test to: • Ensure emergency power to the pump.	NFPA 25, Section 5-5.1	1 to 2 years
Exhaust system inspection for: • Leakage.	NFPA 25, Section 5-5.1	Semiannually

Fuel level inspection to: • Ensure sufficient fuel quantity for the diesel engine system.	NFPA 25, Section 5-5.1	Semiannually and after operation
Fuel quality inspection to: • Ensure proper fuel quality for diesel engine operation.	NFPA 25, Section 5-5.1	Semiannually
Fuse inspection to: • Ensure no blown fuses.	NFPA 25, Section 5-5.1	Semiannually
Fuse replacement for: • Preventive fuse maintenance.	NFPA 25, Section 5-5.1	As necessary
Isolation switch operation to: • Ensure isolation switch operates correctly.	NFPA 25, Section 5-5.1	Semiannually
Lubricate bearings to: • Prevent seizure.	NFPA 25, Section 5-5.1	1 to 2 years
Lubricate coupling to: • Prevent seizure.	NFPA 25, Section 5-5.1	1 to 2 years
Lubricate right-angle gear drive to: • Prevent seizure.	NFPA 25, Section 5-5.1	1 to 2 years
Manual start operation to: • Ensure manual start operates properly.	NFPA 25, Section 5-5.1	1 to 2 years
Pressure switch setting inspection to: • Ensure pump operates through proper range.	NFPA 25, Section 5-5.1	Annually
Circulation relief valve inspection to: • Ensure sufficient water flows through the valve to prevent pump overheating.	NFPA 25, Section 9-5.4.1	Semiannually
Pressure relief valve (PRV) inspection to: • Ensure pressure downstream of the valve does not exceed system component ratings.	NFPA 25, Section 9-5.4.2	Semiannually
PRV test to: • Verify correct settings.	NFPA 25, Section 9-5.4.2.2	See "Fire Pump Flow Test"

Table 3.2.13 Water Supply Tanks

Water level/condition inspection to: • Ensure proper water level; and • Proper water condition.	NFPA 25, Section 6-2.1	Quarterly/Annually[1]
External tank inspection for: • Physical damage; • Accumulation, erosion or storage in the area around tank; and • Ice build-up.	NFPA 25, Section 6-2.2	Not required
Internal tank inspection for: • Corrosion.	NFPA 25, Section 6-2.4	3 years/5 years[2]
Wooden tank hoops and grillage inspection: • Corrosion.	NFPA 25, Section 6-2.5	Not required
Air pressure inspection to: • Ensure proper air pressure.	NFPA 25, Section 6-2.7	Annually
Heating system inspection to: • Ensure proper water temperature.	NFPA 25, Section 6-2.8	Daily when freezing (unsupervised)
Water temperature inspection: • Ensure proper water temperature.	NFPA 25, Section 6-2.9	Daily when freezing (unsupervised)
Expansion joint inspection for: • Leaks and cracks.	NFPA 25, Section 6-2.10	Not required
Level indicator test to ensure: • Accuracy; and • Freedom of movement.	NFPA 25, Section 6-3.1	5 years
Heating system test to ensure: • Proper operation.	NFPA 25, Section 6-3.2	Annually[5]
Low water temperature alarm to ensure: • Proper operation.	NFPA 25, Section 6-3.3	Annually[6]
High water temperature alarm to ensure: • Proper operation.	NFPA 25, Section 6-3.4	Annually
High/low water level alarm to ensure: • Proper operation.	NFPA 25, Section 6-3.5	1 to 2 years
Pressure gauge test to ensure: • Calibration; and • Accuracy.	NFPA 25, Section 6-3.6	5 years
Cathodic protection maintenance to: • Ensure proper operation	NFPA 25, Section 6-4.5	1 to 2 years

Tank thermometer maintenance to: • Ensure proper operation.	NFPA 25, Section 6-4.7	Manufacturer's recommendation
Drain valve operation to ensure: • Operability.	NFPA 25, Section 6-4.8	Not required
Tank vent cleaning to: • Ensure proper operation.	NFPA 25, Section 6-4.9	As necessary
Valve inspection for: • Proper position; and • Physical damage or impairment.	NFPA 25, Section 9-3.3.1	Semiannually/ Annually*
Valve operation test for: • Proper operability.	NFPA 25, Section 9-3.4.2	1 to 2 years
Check valve interior inspection to: • Ensure proper operation.	NFPA 25, Section 9-4.2.1	5 years
Low water level alarm response	N/A	As necessary
High water level alarm response	N/A	As necessary
Low water temperature alarm response	N/A	As necessary
Response to loss of potable water supply	N/A	As necessary

1 – Annual inspection allowed for tanks with supervised water level alarms.
2 – Steel tanks without cathodic protection and all pressure tanks shall be inspected every 3 years.
3 – During cold weather months only.
4 – While heating system is in service.
*Unsupervised/supervised

Table 3.2.14 Dry Chemical Systems

ITM Task	NFPA Reference	Task Frequency
Dry chemical system inspection including: • Correct system location; • Unobstructed manual actuators; and • Physical system condition.	NFPA 17, Section 9-2.1	Semiannually
Dry chemical system maintenance including: • Detailed examination of all components; • Check for unobstructed piping; • Dry chemical examination; • Hydrostatic testing when necessary; and • Actuation system test w/o release.	NFPA 17, Section 9-3.1	Semiannually
Fusible-metal link replacement to prevent: • Delayed actuation from contaminant loading.	NFPA 17, Section 9-3.2	1 to 2 years
Fixed T-sensing elements inspection and cleaning to prevent: • Delayed actuation from contaminant loading.	NFPA 17, Section 9-3.3	1 to 2 years

Table 3.2.15 Wet Chemical Systems

Wet chemical system inspection Including: • Correct system location; • Unobstructed manual actuators; and • Physical system condition.	NFPA 17A, Section 5-2.1	Semiannually
Wet chemical system maintenance including: • Detailed examination of all components; • Check for unobstructed piping; • Hydrostatic testing when necessary; and • Actuation system test w/o release.	NFPA 17A, Section 5-3.1	Semiannually
Fusible-metal link replacement to prevent: • Delayed actuation from contaminant loading.	NFPA 17A, Section 5-3.2	1 to 2 years
Fixed temperature-sensing elements inspection and cleaning to prevent: • Delayed actuation from contaminant loading.	NFPA 17A, Section 5-3.3	1 to 2 years

Table 3.2.16 Halon Systems

ITM Task	NFPA Reference	Task Frequency
Thorough inspection and test including: • Detection (proper alarms and functions); • Actuation (detection actuation interface); • Agent supply (container condition); • Piping and nozzles (condition and orientation); and • Auxiliary equipment (enclosure interfaces).	NFPA 12A, Sections 4-1.1 and A-4-1	1 to 2 years
Refillable container inspection to ensure: • Sufficient agent quantity; and • Agent pressure.	NFPA 12A, Section 4-1.3	1 to 2 years
Non-refillable container inspection to ensure: • Sufficient agent quantity.	NFPA 12A, Section 4-1.5	1 to 2 years
Cylinder test to ensure: • Suitability for use.	NFPA 12A, Section 4-2.1	5 years
Complete external inspection of non-discharged cylinders to ensure: • Suitability for use.	NFPA 12A, Section 4-2.2	5 years
Hose inspection for: • Damage.	NFPA 12A, Section 4-3	Not required
Hose test to ensure: • Suitability for use.	NFPA 12A, Section 4-3.2	5 years
Enclosure inspection to ensure: • Sufficient enclosure integrity to provide the proper extinguishment concentration.	NFPA 12A, Section 4-4	Every two years and after modifications

Table 3.2.17 Halon Alternative Systems

Thorough inspection and test including: • Detection (proper alarms and functions); • Actuation (detection actuation interface); • Agent supply (container condition); • Piping and nozzles (condition and orientation); and • Auxiliary equipment (enclosure interfaces).	NFPA 2001, Section 4-1.1	1 to 2 years
Refillable container inspection to ensure: • Sufficient agent quantity; and • Agent pressure.	NFPA 2001, Section 4-1.3	1 to 2 years
Non-refillable container inspection to ensure: • Sufficient agent quantity.	NFPA 2001, Section 4-1.5	1 to 2 years
Cylinder test to ensure: • Suitability for use.	NFPA 2001, Section 4-2.1	5 years
Complete external inspection of non-discharged cylinders to ensure: • Suitability for use.	NFPA 2001, Section 4-2.2	5 years
Hose inspection for: • Damage.	NFPA 2001, Section 4-3.1	Not required
Hose test to ensure: • Suitability for use.	NFPA 2001, Section 4-3.2	5 years
Enclosure inspection to ensure: • Sufficient enclosure integrity to provide the proper extinguishment concentration.	NFPA 2001, Section 4-4	Every two years and after modifications

Table 3.2.18 Carbon Dioxide Systems

ITM Task	NFPA Reference	Task Frequency
System operational conditions inspection ensuring, as a minimum, that: • High pressure cylinders are in place and secure; • Low pressure storage unit including liquid level gauge, pressure gauge is normal, and tank shutoff and pilot pressure supply valves are open; • CO_2 storage is connected to discharge piping and actuators; • Manual actuators are in place; • Nozzles are connected, aligned and free of obstructions; • Detectors are in place and free of obstructions; and • System control panel is connected and in "ready" mode.	NFPA 12, Section 1-10.1	Annually
System hose tests at appropriate system pressure to ensure: • Suitability for use.	NFPA 12, Sections 1-10.2 & 1-10.2.1	Not required
Thorough inspection and testing, including: • Overall system physical appearance; • Check all circuits for proper operation; • Exercise all control panel functions and supervision; • Check main and emergency power supplies; • Check all actuation devices; • Check timer and time delay; • Check manual releases for operation; and • Check all piping, nozzles, and containers.	NFPA 12 Secs. 1-10.3, .3.2, & A-1.10.3	1 to 2 years
Full discharge to ensure: • Proper system operation.	NFPA 12, Section 1-10.3.2.2	Not required
High pressure cylinder weight to ensure: • Sufficient quantity of CO_2.	NFPA 12, Section 1-10.3.5	1 to 2 years
Low pressure cylinder liquid level gauges to ensure: • Sufficient quantity of CO_2	NFPA 12, Section 1-10.3.6	Semiannually

4. CONCLUSIONS

4.1 Conclusions

This study has clearly demonstrated:

- It is possible to develop a risk based reliability centered maintenance concept for DOD fire protection systems.
- Many current prescriptive maintenance requirements in consensus-based codes do not directly contribute to the ability of a system to effectively respond to a fire event.
- 99% reliability is achievable with a relative modest investment in system maintenance activities.

4.2 Recommendation

The recommended ITM frequencies in Chapter 3 be incorporated in to a new DOD guidance for the maintenance, test and inspection of fire protection systems replacing the current Tri-Service manual, AFM 91-37 (AFJMAN 32-1059), MO-117, TM 5-695 and national consensus code prescriptive requirements.

APPENDIX A

Component Worksheets

APPENDIX A

Component Worksheets

A.1 PURPOSE

This appendix provides a description of the component worksheets that were used to develop the ITM guides. In addition, this appendix contains the component worksheets for each fire protection system.

A.2 COMPONENT WORKSHEET DESCRIPTION

Each component worksheet contains five major columns: **Failure Mode**, **Risk Characterization**, **Causes**, **ITM Tasks**, and **Frequency**. The frequency column is subdivided into NFPA and recommended frequencies. Below is a description of the information in each column:

- Failure Mode — This column lists the failure modes for a component that were analyzed and identified during the FMEA as resulting in a functional failure of interest.

- Risk Characterization — This column lists the PFOD ranking and system degradation level ranking from the risk characterization performed during the RCM analysis. A two-letter designation is used to indicate the risk characterizations. The first letter provides the system degradation level ranking, and the second letter provides the PFOD ranking. For example, TM represents a system degradation level ranking of total (T) and a PFOD ranking of medium (M). Tables A.1 and A.2 provide the letter designation for system degradation level rankings and PFOD rankings, respectively.

- Causes — This column lists the causes for the failure mode that were identified in the FMEA. These are the specific failures that the ITM tasks are attempting to prevent or detect.

- ITM Tasks — This column lists the applicable ITM tasks from the NFPA codes.

- NFPA Frequency — This column provides the frequency prescribed in the NFPA code for the task.

- Recommended Frequency — This column provides the recommended frequency from the frequency assessment performed during the RCM analysis.

Table A.1 Letter Designations for System Degradation Level Rankings

System Degradation Level Ranking	Letter Designation
Total	T
Partial	P
Minimal	M

Table A.2 Letter Designations for PFOD Rankings

PFOD Ranking	Letter Designation
High	H
Medium	M
Low	L
Very Low	V

A.3 COMPONENT WORKSHEETS

The following subsections contain the component worksheets for each fire protection system.

Fire Alarm Systems [Dedicated AC Power (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails with no supply from system	TM	Mechanical damage	Supervisory alarm response	As necessary	As necessary
		Inadvertent connection	Supervisory alarm response	As necessary	As necessary
		Failure in power generation system and/or distribution system	Supervisory alarm response	As necessary	As necessary
Improper supply characteristics: voltage	TV	Failure at power generation source	Control eqpt inspection (Section 7-3.1[1-2])	Weekly/annually	1 to 2 years/ Not required
			Control eqpt. test (Section 7-3.2[1-2a])	Quarterly/annual	Not required
			Lamps/LEDs (Section 7-3.2[1-2d])	Quarterly/annual	Not required
			Primary power (Section 7-3.2[1-2e])	Quarterly/annual	Not required

Fire Alarm Systems [Secondary Power via Batteries (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to operate for sufficient length of time when AC power is lost	TM	Drain down due to grounding	Supervisory alarm response	As necessary	As necessary
		Age of the batteries	Supervisory alarm response	As necessary	As necessary
		Overcharging of batteries	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., heat, humidity)	Supervisory alarm response	As necessary	As necessary
		Undercharging of batteries	Supervisory alarm response	As necessary	As necessary
		Failure of the batteries to hold a charge	Supervisory alarm response	As necessary	As necessary
Fails to recharge	TV	Power supply board charger failure	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Hardwired System Control Panel Processor Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to completely execute logic (or logic is not executed in a timely manner)	TM (relay) TL (firmware)	Firmware memory erased (e.g., lightning, light exposure)	Supervisory alarm response	As necessary	As necessary
		Faults in upgraded firmware	Supervisory alarm response	As necessary	As necessary
		Improper system database programming	Supervisory alarm response	As necessary	As necessary
		Failure of a relay to transfer a signal	Supervisory alarm response	As necessary	As necessary
		Improper relay installation during maintenance	Supervisory alarm response	As necessary	As necessary
Improper logic execution	TM (relay) TL (database)	Relay failure	Supervisory alarm response	As necessary	As necessary
		Improper relay installation during maintenance	Supervisory alarm response	As necessary	As necessary
		Improper system database programming	Supervisory alarm response	As necessary	As necessary
Failure to receive voltage from the zone card	PL	Zone card connection not made or loose	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., humidity, heat)	Supervisory alarm response	As necessary	As necessary
		Processor board card not made or loose	Supervisory alarm response	As necessary	As necessary
Fails to communicate (transmit and receive) with the notification appliance card	PV	Processor board component failure	Supervisory alarm response	As necessary	As necessary
		Processor board card connection not made or loose	Supervisory alarm response	As necessary	As necessary
		Notification card connection not made or loose	Supervisory alarm response	As necessary	As necessary
		Failure of the control panel devices (e.g., LED, LCD, horn)	Supervisory alarm response	As necessary	As necessary

Fails to send voltage to the control panel annunciator	PV	Connection to the control panel annunciator not made or loose	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Failure of a processor board component	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Hardwired System Control Panel Notification Appliance Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to communicate with the processor board	PV	Notification appliance card connection not made or loose	Notification appliance test (Section 7-3.2[18]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Environmental conditions (e.g., heat, humidity)	Notification appliance test (Section 7-3.2[18]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to change state (i.e., energize the notification appliance)	PV	Notification appliance board component failure	Notification appliance test (Section 7-3.2[18]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Environmental conditions (e.g., heat, humidity)	Notification appliance test (Section 7-3.2[18]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Hardwired System Control Panel Initiating Device Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to communicate with the processor board	PV	Initiating device card connection not made or loose	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary
		Environmental conditions (e.g., heat, humidity)	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary

Fails to change state (i.e., does not sense change in initiating device)	PV (others) PM (relay)	Initiating device board component failure	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary
		Environmental conditions (e.g., heat, humidity)	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary
		Relay failure	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	1 to 2 years As necessary

Fire Alarm Systems [Hardwired System Control Panel Remote Annunciator Board and Annunciator (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to communicate with the processor board	PL	Remote annunciator board connection not made or loose	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Open in the wiring to the remote annunciator	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Environmental conditions (e.g., heat, humidity)	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Fails to change state (e.g., turn on/off light/horn)	PL	Remote annunciator board component failure	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Burned out	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Mechanical damage to the horn	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Open in the wiring to the remote annunciator	Annunciator test (Section 7-3.2[13]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Spurious operation of light/horn	MV	Short in the wiring to the remote annunciator system	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Hardwired System Control Panel Central Interface (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Failure to communicate with the control panel	PL	Central station interface connection not made or loose	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., heat, humidity)	Supervisory alarm response	As necessary	As necessary
Fails to change state (i.e., "normal" to "alarm")	PV	Central station interface component failure	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., heat, humidity)	Supervisory alarm response	As necessary	As necessary
Fails to transmit signal to the DACT	PL	Connection to the DACT not made or loose	DACT test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Environmental conditions (e.g., heat, humidity)	DACT test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Hardwired System Control Panel City Box Tie-in (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Failure to communicate with the control panel	PL	City box tie-in connection not made or loose	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., heat, humidity)	Supervisory alarm response	As necessary	As necessary
		Open in the wiring to the city box	Supervisory alarm response	As necessary	As necessary
Fails to change state (i.e., "normal" to "alarm")	PV	Failure of city box components	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., heat, humidity)	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Intelligent/Analog System Control Panel Microprocessor Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to completely execute logic (or logic is not executed in a timely manner)	TL	Firmware memory erased (e.g., lightning, light exposure)	Supervisory alarm response	As necessary	As necessary
		Faults in upgraded firmware	Supervisory alarm response	As necessary	As necessary
		Improper system database programming	Supervisory alarm response	As necessary	As necessary
		Microprocessor failure	Supervisory alarm response	As necessary	As necessary
Improper logic execution	TL	Microprocessor failure	Supervisory alarm response	As necessary	As necessary
		Improper system database programming	Supervisory alarm response	As necessary	As necessary
Fails to communicate with the signaling line circuit card	TL	Loose board connection	Supervisory alarm response	As necessary	As necessary
		Board connection corrosion	Supervisory alarm response	As necessary	As necessary
		Microprocessor failure	Supervisory alarm response	As necessary	As necessary
Fails to communicate with the notification appliance card	PL	Loose board connection	Supervisory alarm response	As necessary	As necessary
		Board connection corrosion	Supervisory alarm response	As necessary	As necessary
		Microprocessor failure	Supervisory alarm response	As necessary	As necessary
Fails to communicate with the DACT/central interface	PL	Loose board connection	Supervisory alarm response	As necessary	As necessary
		Board connection corrosion	Supervisory alarm response	As necessary	As necessary
		Microprocessor failure	Supervisory alarm response	As necessary	As necessary

Fails to communicate with the control panel annunciator	MV	Loose board connection	Supervisory alarm response	As necessary	As necessary
		Microprocessor failure	Supervisory alarm response	As necessary	As necessary
		Board corrosion connection	Supervisory alarm response	As necessary	As necessary
Fails to communicate with slave control panels	TL	Network connection loss	Supervisory alarm response	As necessary	As necessary
		Network interface board failure	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Intelligent/Analog System Control Panel Notification Appliance Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to energize the notification appliance	PV	Board relay failure	Supervisory alarm response	As necessary	As necessary
		Board circuitry failure	Supervisory alarm response	As necessary	As necessary
		Loose board and/or wiring connection	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Intelligent/Analog Control Panel Signaling Line Circuit Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to change state (i.e. does not sense change in initiating device)	TV	Loose connection	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary
		Board circuitry failure	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary

Fire Alarm Systems [Intelligent/Analog System Control Panel LCD/Alphanumeric Display (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to display correct information	MV	Loose connection	Supervisory alarm response	As necessary	As necessary
		Display failure	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Intelligent Analog System Control Panel DACT or Central Station Interface (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to interrupt the signal properly and/or execute proper action	PL	Phone line loss (DACT only)	DACT test (Section 7-3.2[20a]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose phone connection (DACT only)	DACT test (Section 7-3.2[20a]) Supervisory alarm response	Annually As necessary	Not required As necessary
		DACT/central station interface board circuitry failure	DACT test (Section 7-3.2[20a]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Radio Transmitter System Control Panel Microprocessor Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to completely execute logic (or logic is not executed in a timely manner)	TL	Firmware memory erased (e.g., lightning, light exposure)	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Upgraded firmware faults	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Improper system database programming	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Improper logic execution	TL	Improper system database programming	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary

Fails to transmit to the radio transmitter	PL	Loose connections	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loss of connection between the control panel and transmitter panel	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Radio Transmitter System Control Panel Transmitter (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to transmit signal	PL	Signal interrupted due to natural weather phenomena	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Mechanical damage to the antenna	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Transient noise	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Transmitter circuitry failure	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary
Transmits incorrect/ Incomplete signal	PL	Transient noise	DART test (Section 7-3.2[20b]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Control Panel Power Supply (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails with no low output voltage/current	TL	Voltage spike entering the system (e.g., lightning)	Control panel inspection (Section 7-3.1[1-2]) Power supply test (Section 7-3.2[1-2]) Supervisory alarm response	Quarterly/annual Weekly/annually As necessary	1 to 2 years Semiannually/ 1 to 2 years As necessary
		Loose connection	Control panel inspection (Section 7-3.1[1-2]) Power supply test (Section 7-3.2[1-2]) Supervisory alarm response	Quarterly/annual Weekly/annually As necessary	1 to 2 years Semiannually/ 1 to 2 years As necessary
		Environmental conditions (e.g., heat, humidity)	Control panel inspection (Section 7-3.1[1-2]) Power supply test (Section 7-3.2[1-2]) Supervisory alarm response	Quarterly/annual Weekly/annually As necessary	1 to 2 years Semiannually/ 1 to 2 years As necessary
Fails to transfer correctly (i.e., change AC to DC voltage)	TV	Transformer failure	Control panel inspection (Section 7-3.1[1-2]) Power supply test (Section 7-3.2[1-2]) Supervisory alarm response	Quarterly/annual Weekly/annually As necessary	Not required 1 to 2 years/ Not required As necessary

Fire Alarm Systems [Control Panel Batteries (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to operate for sufficient length of time	TM	Battery failure	Supervisory alarm response	As necessary	As necessary
		Battery charger failure	Supervisory alarm response	As necessary	As necessary
		Failure of the batteries to hold a charge	Supervisory alarm response	As necessary	As necessary

Fails to recharge	TL	Power supply failure	Supervisory alarm response	As necessary	As necessary
		Loose connection	Supervisory alarm response	As necessary	As necessary
		Battery leads corrosion	Supervisory alarm response	As necessary	As necessary
		Environmental conditions (e.g., humidity, heat)	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Smoke Detector on an IDC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/fouled	TL (all) PL (one)	External debris buildup (e.g., beehive)	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	Not required Not required
		Dirt buildup	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	1 to 2 years 1 to 2 years
		Covering of the detector (e.g., leaving material on the detector after painting)	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	1 to 2 years 1 to 2 years
		Coating of the detector with foreign material (e.g., paint)	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	1 to 2 years 1 to 2 years
Failure to detect the presence of smoke	PM (one) TL (all)	Light source failure	Functional test (Section 7-3.2 [14h]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Receiver failure	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Labyrinth chamber failure (PE type)	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Electrode failure	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Electrode corrosion	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary

		Dirt on the detection cell	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Contacts failure (e.g., broken springs)	Functional test (Section 7-3.2 [14h]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Contact surfaces corrosion	Functional test (Section 7-3.2 [14h]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary

** - Sensitivity test shall be performed first year after installation, then biannually under most circumstances. Refer to NFPA 72.

Fire Alarm Systems [Smoke Detector on an SLC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ Fouled	PL (one) TL (all)	External debris buildup (e.g., beehive)	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	Not required Not required
		Dirt buildup from the environment	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	1 to 2 years 1 to 2 years
		Covering of the detector (e.g., material on the detector after painting)	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	1 to 2 years 1 to 2 years
		Coating of the detector with foreign material (e.g., paint)	Visual inspection (Section 7-3.1 [9h]) Functional test (Section 7-3.2 [14h])	Semiannually Annually	1 to 2 years 1 to 2 years
Failure to detect the presence of smoke	PM (one) TM (all)	Light source failure	Functional test (Section 7-3.2 [14h]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Receiver failure	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Labyrinth chamber failure (PE type)	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Electrode failure	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Electrode corrosion	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary

		Dirt on the detection cell	Functional test (Section 7-3.2 [14h]) Sensitivity test (Section 7-3.2.1) Supervisory alarm response	Annually ** As necessary	1 to 2 years ** As necessary
		Improper detector database programming	Functional test (Section 7-3.2 [14h])	Annually	Semiannually
Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Improper detector database programming	Functional test (Section 7-3.2 [14h])	Annually	1 to 2 years
		Detector microprocessor failure	Functional test (Section 7-3.2 [14h]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Loss of or poor communication	Functional test (Section 7-3.2 [14h]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Activates at lower set point	MM	Improper detector database programming	Functional test (Section 7-3.2 [14h])	Annually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14h])	Annually	Not required
Activates at a higher set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14h])	Annually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14h])	Annually	Not required

** - Sensitivity test shall be performed first year after installation, then biannually under most circumstances. Refer to NFPA 72.

Fire Alarm Systems [Heat Detector on an IDC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ Fouled	PV (one) TV (all)	External debris buildup (e.g., beehive)	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required Not required
		Dirt buildup from the environment	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required Not required
		Covering of the detector (e.g., leaving tape/plastic bags on the detector after painting)	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required Not required
		Coating of the detector with foreign material (e.g., paint)	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required Not required
Failure to detect temperature increase	PV (one) TV (all)	Open circuit in the temperature sensing element	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	Not required As necessary

		Loose connection	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Corrosion	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Contacts failure (e.g., broken springs)	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Contact surfaces corrosion	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Activates at a lower set point	ML	Improper detector setting	Functional test (Section 7-3.2 [14e])	Annually	Not required
Activates at a higher set point	ML	Improper detector setting	Functional test (Section 7-3.2 [14e])	Annually	Not required

Fire Alarm Systems [Heat Detector on an SLC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ fouled	PV (one) TV (all)	External debris buildup (e.g., beehive)	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required
		Dirt buildup from the environment	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required
		Covering of the detector (e.g., leaving material on the detector after painting)	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required
		Coating of the detector with foreign material (e.g., paint)	Visual inspection (Section 7-3.1 [9f]) Functional test (Section 7-3.2 [14e])	Semiannually Annually	Not required
Failure to detect temperature increase	PL (one) TL (all)	Open circuit in the temperature sensing element	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Corrosion	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Improper detector database programming	Functional test (Section 7-3.2 [14e])	Annually	1 to 2 years
Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Improper detector database programming	Functional test (Section 7-3.2 [14e])	Annually	1 to 2 years
		Detector microprocessor failure	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Loss of or poor communication	Functional test (Section 7-3.2 [14e]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary

Activates at lower set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14e])	Annually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14e])	Annually	Not required
Activates at a higher set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14e])	Annually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14e])	Annually	Not required

Fire Alarm Systems [Flame Detector on an IDC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ Fouled	PL (one) TL (all)	Physical obstruction in front of the detector	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
		Dirt buildup	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
		Covering of the detector (e.g., leaving tape/plastic bags on the detector after painting)	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
		Coating of the detector with foreign material (e.g., paint)	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
Fails to detect the presence of a flame	PM (one) TM (all)	Light sensitive element failure	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary
		Cathode-ray tube failure	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary
Fails to change state (i.e., from "non-alarm" to "alarm")	PV (one) TV (all)	Contacts failure (e.g., broken springs)	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary
		Contact surfaces corrosion	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary

Fire Alarm Systems [Flame Detector on an SLC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ Fouled	PL (one) TL (all)	Physical obstruction in front of the detector	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
		Dirt buildup	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
		Covering of the detector (e.g., leaving tape/plastic bags on the detector after painting)	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
		Coating of the detector with foreign material (e.g., paint)	Visual inspection (Section 7-3.1 [9g]) Functional test (Section 7-3.2 [14g])	Quarterly Semiannually	1 to 2 years
Fails to detect the presence of a flame	PL (one) TL (all)	Light sensitive element failure	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary
		Cathode-ray tube failure	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary
		Improper detector database programming	Functional test (Section 7-3.2 [14g])	Semiannually	1 to 2 years
		Detector microprocessor failure	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	1 to 2 years As necessary
Fails to change state (i.e., from "non-alarm" to "alarm")	PV (one) TL (all)	Detector microprocessor failure	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	Not required As necessary
		Improper detector database programming	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	Not required As necessary
		Loss of or poor communication	Functional test (Section 7-3.2 [14g]) Supervisory alarm response	Semiannually As necessary	Not required As necessary
Activates at lower set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14g])	Semiannually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14g])	Semiannually	Not required
Activates at a higher set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14g])	Semiannually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14g])	Semiannually	Not required

Fire Alarm Systems [Gas Detector on an IDC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ Fouled	PL (one) TL (all)	Physical obstruction of the detector	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Dirt buildup from the environment	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Covering of the detector (e.g., leaving tape/plastic bags on the detector after painting)	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Coating of the detector with foreign material (e.g., paint)	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
Fails to detect presence of gas	PL (one) TL (all)	Physical obstruction of the detector	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Catalytic bead failure	Functional test (Section 7-3.2 [14d]) Supervisory alarm	Annually As necessary	1 to 2 years As necessary
Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Contacts failure (e.g., broken springs)	Functional test (Section 7-3.2 [14d]) Supervisory alarm	Annually As necessary	1 to 2 years As necessary
		Contact surfaces corrosion	Functional test (Section 7-3.2 [14d]) Supervisory alarm	Annually As necessary	1 to 2 years As necessary
Activates at a lower set point	ML	Improper setting of the detector	Functional test (Section 7-3.2 [14d])	Annually	Not required
Activates at a higher set point	ML	Improper setting of the detector	Functional test (Section 7-3.2 [14d])	Annually	Not required

Fire Alarm Systems [Gas Detector on an SLC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Inlet to detector plugged/blocked/ fouled	PL (one) TL (all)	Physical obstruction in front of the detector	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Dirt buildup	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Covering of the detector (e.g., leaving tape/plastic bags on the detector after painting)	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Coating of the detector with foreign material (e.g., paint)	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
Fails to detect presence of gas	PL (one) TL (all)	Physical obstruction of the detector	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Catalytic bead failure	Functional test (Section 7-3.2 [14d]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Improper detector database programming	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
		Detector microprocessor failure	Functional test (Section 7-3.2 [14d]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Detector microprocessor failure	Functional test (Section 7-3.2 [14d]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Loss of or poor communication	Functional test (Section 7-3.2 [14d]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Improper detector database programming	Functional test (Section 7-3.2 [14d])	Annually	1 to 2 years
Activates at lower set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14d])	Annually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14d])	Annually	Not required
Activates at a higher set point	ML	Improper detector database programming	Functional test (Section 7-3.2 [14d])	Annually	Not required
		Detector microprocessor failure	Functional test (Section 7-3.2 [14d])	Annually	Not required

Fire Alarm Systems [City Box on an IDC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to communicate to the local system	PL	Loose connection	Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Intelligent Manual Pull Station (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive supervisory signal from the microprocessor board	MV	Carrier loss	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Power supply failure	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to receive operating signal from the microprocessor board	PV (one) TV (all)	Carrier loss	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Power supply failure	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fails to change state (i.e., from "non-alarm" to "alarm")	PL (one) TL (all)	Carrier loss	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Switch inoperable	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Switch arm dirty	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Broken mechanism	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
Access to manual pull station blocked	PM (one) TM (all)	Physical obstruction in front of the manual pull station	Visual inspection (Section 7-3.1[9e])	Semiannually	Annually
Fails to communicate with the SLC board	PV (one) TV (all)	Carrier loss	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Fire alarm box test (Section 7-3.2[14f]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Waterflow Switch on an IDC (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Flapper stuck in position	PV	Debris buildup in piping	Alarm device test (Section 2-3.3)	Quarterly	Not required
Activates at a lower set point	ML	Improper switch setting	Alarm device test (Section 2-3.3)	Quarterly	Not required
Activates at a higher set point	ML	Improper switch setting	Alarm device test (Section 2-3.3)	Quarterly	Not required

Fire Alarm Systems [Pressure Switch on an IDC (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to respond to an input change	PL	Plugging of the tap	Alarm device test (Section 2-3.3)	Quarterly	Not required
Activates at a lower set point	MV	Improper switch setting	Alarm device test (Section 2-3.3)	Quarterly	Not required
Activates at a higher set point	MV	Improper switch setting	Alarm device test (Section 2-3.3)	Quarterly	Not required

Fire Alarm Systems [Intelligent Input Modules Interfacing with Suppression System Flow and Pressure Switches (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive supervisory signal from the microprocessor board	MV	Carrier loss	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Power supply failure	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Loose connection	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Connection corrosion	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
Fails to receive operating signal from the microprocessor board	PV	Carrier loss	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Power supply failure	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Loose connection	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Connection corrosion	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary

Fails to change state (i.e., from "non-alarm" to "alarm")	PV	Carrier loss	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Loose connection	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Connection corrosion	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
Fails to communicate with input devices	PV	Carrier loss	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Loose connection	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary
		Connection corrosion	Alarm device test (Section 2-3.3) Supervisory alarm response	Quarterly As necessary	Not required As necessary

Fire Alarm Systems [Fire Safety Equipment Control Remote Relays (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails open (for NO relay)	PL	Burnt out relay coil	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Dirty contacts	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Contact corrosion	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails closed (for NO relay)	ML	Sticking of the contacts	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Contact failure (e.g., broken spring)	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails open (for NC relay)	ML	Burnt out relay coil	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Dirty contacts	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Contact corrosion	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails closed (for NC relay)	PL	Sticking of the contacts	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Contact failure (e.g., broken spring)	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary

Short circuit (for NO relay)	ML	Wiring insulation failure	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Short circuit (for NC relay)	PL	Wiring insulation failure	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Deluge/Pre-action Releasing Module (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to open	TL	Plugging of the solenoid valve outlet	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16])	Annually Annually	1 to 2 years 1 to 2 years
		Failure to receive actuation signal	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16])	Annually Annually	1 to 2 years 1 to 2 years
		Jamming/sticking of the solenoid	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16])	Annually Annually	1 to 2 years 1 to 2 years
		Loss of electricity	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
Opens prematurely	ML	Spurious actuation signal from the fire detection system	Waterflow alarm response	As necessary	As necessary

Fire Alarm Systems [Releasing Module Board (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive supervisory signal from the microprocessor board	MV	Carrier loss	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Power supply failure	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Loose connection	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary

		Connection corrosion	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
Fails to receive operating signal from the microprocessor board	PV (one) TV (all)	Carrier loss	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Power supply failure	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Loose connection	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Connection corrosion	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
Fails to energize the release device	PL (one) TL (all)	Carrier loss	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Loose connection	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Connection corrosion	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Solenoid failure	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16])	Annually Annually	1 to 2 years 1 to 2 years
		Improper releasing module database programming	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16])	Annually Annually	1 to 2 years 1 to 2 years

Fire Alarm Systems [Releasing Module Board (NFPA 72)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to communicate with the release module	PL (one) TL (all)	Carrier loss	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Loose connection	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Connection corrosion	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Improper releasing module database programming	Switch operation (Section 7-3.2 [14c]) Special hazard equipment (Section 7-3.2[16])	Annually Annually	1 to 2 years 1 to 2 years

Fire Alarm Systems [Intelligent Interface Modules for IDCs (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive supervisory signal from the microprocessor board	PV	Carrier loss	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary
		Power supply failure	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary
		Loose connection	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary

		Connection corrosion	Initiating device test (Section 7-3.2[14]) Supervisory alarm response	Quarterly/ Semiannually/ Annually As necessary	Not required As necessary

Fire Alarm Systems [Intelligent Interface Modules for IDCs (NFPA 72)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive operating signal from the microprocessor board	PV (one) TV (all)	Carrier loss	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary
		Power supply failure	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary
		Loose connection	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary
		Connection corrosion	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary
Fails to receive signal from the IDC	PV (one) TV (all)	Carrier loss	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary
		Loose connection	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary
		Connection corrosion	Initiating device test (Section 7-3.2[14])	Quarterly/ Semiannually/ Annually	Not required
			Supervisory alarm response	As necessary	As necessary

Fire Alarm Systems [Intelligent Interface Modules for Equipment Operational Status (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive supervisory signal from the microprocessor board	MV	Carrier loss	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Power supply failure	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to receive operating signal from the microprocessor board	MV	Carrier loss	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Power supply failure	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to change state	MV	Carrier loss	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface eqpt. test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Intelligent Interface Modules for Fire Safety Related Equipment Control (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive supervisory signal from the microprocessor board	MV	Carrier loss	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Power supply failure	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to receive operating signal from the microprocessor board	PV	Carrier loss	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Power supply failure	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to energize the connected appliance	PV	Carrier loss	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
Fails to communicate with the output devices	PV	Carrier loss	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Loose connection	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary
		Connection corrosion	Interface equipment test (Section 7-3.2[16]) Supervisory alarm response	Annually As necessary	Not required As necessary

Fire Alarm Systems [Horn (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to operate on demand	PL (one) TL (all)	Loose connection	Audibility test (Section 7-3.2 [18a]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Inadequate voltage to the horn	Audibility test (Section 7-3.2 [18a]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Fails off after activation	PL (one) TL (all)	Loose connection	Supervisory alarm response	As necessary	As necessary
		Inadequate voltage to the horn	Supervisory alarm response	As necessary	As necessary
Improper operating characteristic: volume	PL (one) TL (all)	Incorrectly reset after activation	Audibility test (Section 7-3.2 [18a])	Annually	1 to 2 years
		Inadequate voltage to the horn	Audibility test (Section 7-3.2 [18a])	Annually	1 to 2 years

Fire Alarm Systems [Strobe (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to operate on demand	PL (one) TL (all)	Loose connection	Visibility test (Section 7-3.2 [18c]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Inadequate voltage to the strobe	Visibility test (Section 7-3.2 [18c]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Fails off after activation	PL (one) TL (all)	Loose connection	Supervisory alarm response	As necessary	As necessary
		Inadequate voltage to the strobe	Supervisory alarm response	As necessary	As necessary
Improper operating characteristic: light	PL (one) TL (all)	Incorrectly reset after activation	Visibility test (Section 7-3.2 [18c])	Annually	1 to 2 years
		Inadequate voltage to the strobe	Visibility test (Section 7-3.2 [18c])	Annually	1 to 2 years

Fire Alarm Systems [Bell (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to operate on demand	PL (one) TL (all)	Loose connection	Audibility test (Section 7-3.2 [18a]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
		Inadequate voltage to the bell	Audibility test (Section 7-3.2 [18a]) Supervisory alarm response	Annually As necessary	1 to 2 years As necessary
Fails off after activation	PL (one) TL (all)	Loose connection	Supervisory alarm response	As necessary	As necessary
		Inadequate voltage to the bell	Supervisory alarm response	As necessary	As necessary
Improper operating characteristic: volume	PL (one) TL (all)	Incorrectly reset after activation	Audibility test (Section 7-3.2 [18a])	Annually	1 to 2 years
		Inadequate voltage to the bell	Audibility test (Section 7-3.2 [18a])	Annually	1 to 2 years

Fire Alarm Systems [Combination Notification Appliances (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to operate on demand	PL (one) TL (all)	Loose connection	Audibility test (Section 7-3.2 [18a]) Clarity (Section 7-3.2[18b]) Visibility test (Section 7-3.2 [18c]) Supervisory alarm response	Annually Annually Annually As necessary	1 to 2 years 1 to 2 years 1 to 2 years As necessary
		Inadequate voltage to the notification appliance	Audibility test (Section 7-3.2 [18a]) Clarity (Section 7-3.2[18b]) Visibility test (Section 7-3.2 [18c]) Supervisory alarm response	Annually Annually Annually As necessary	1 to 2 years 1 to 2 years 1 to 2 years As necessary
Fails off after activation	PL (one) TL (all)	Loose connection	Supervisory alarm response	As necessary	As necessary
		Inadequate voltage to the notification appliance	Supervisory alarm response	As necessary	As necessary

Improper operating characteristic: volume, clarity and/or light	PL (one) TL (all)	Incorrectly reset after activation	Audibility test (Section 7-3.2 [18a]) Clarity (Section 7-3.2[18b]) Visibility test (Section 7-3.2 [18c])	Annually Annually Annually	1 to 2 years 1 to 2 years 1 to 2 years
		Inadequate voltage to the notification appliance	Audibility test (Section 7-3.2 [18a]) Clarity (Section 7-3.2[18b]) Visibility test (Section 7-3.2 [18c])	Annually Annually Annually	1 to 2 years 1 to 2 years 1 to 2 years

Fire Alarm Systems [Solenoid Supervision and Releasing Service Equipment from an NAC (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to communicate change of state	PL (one) TL (all)	Improper programming	Interface equipment test (Section 7-3.2[16])	Annually	Not required
		Loose connection	Supervisory alarm response	As necessary	As necessary
		Inadequate voltage	Supervisory alarm response	As necessary	As necessary
Spurious detection change of state	ML	False operation of the detector (e.g., dust in the detector) or solenoid	No ITM task identified for this failure mode	N/A	N/A

Fire Alarm Systems [Voice Notification Modules (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to announce message	PL (one) TL (all)	Loss of carrier	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
		Improper programming of the voice notification module	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
		Voice notification module microprocessor failure	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary

Fire Alarm Systems [Microphone (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to transmit message	PL	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
		Microphone failure	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	Not required Not required As necessary
Improper characteristic: message clarity	PL	Volume set too high	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	Not required Not required

Fire Alarm Systems [Amplifiers (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive input	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
Fails to transmit message	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
Improper characteristic: message volume	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
Improper characteristic: message clarity	PV (one) TV (all)	Transient noise	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years

		Amplifier degradation	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years

Fire Alarm Systems [Automatic Message Generators (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive command to generate message	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
		Automatic message generator processor failure	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
		Improper message generator programming	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
Fails to generate message	PL (one) TL (all)	Inadvertent erasing of the message	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
		Automatic message generator processor failure	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As required	1 to 2 years 1 to 2 years As required
		Improper message generator programming	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
Fails to transmit message	PV (one) TV (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
Generates incorrect message	PL (one) TL (all)	Improper message generator programming	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years

Fire Alarm Systems [Speakers (NFPA 72)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to receive message	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
		Inadequate voltage to the speakers	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
Fails to transmit message	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
		Inadequate voltage to the speakers	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b]) Supervisory alarm response	Annually Annually As necessary	1 to 2 years 1 to 2 years As necessary
Improper characteristic: message clarity	PL (one) TL (all)	Loose connection	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
		Transient noise	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years
		Mechanical damage	Emergency communications equipment test (Section 7-3.2[11]) Speaker test (Section 7-3.2[18b])	Annually Annually	1 to 2 years 1 to 2 years

Water Supply Components [Gravity Feed Storage Tank (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Tank external leak/rupture	TV	Corrosion (steel tanks)	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Rot (wooden tanks)	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Mechanical damage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Tank vent pluggage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
Outlet line external leak/rupture	TV	Mechanical damage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Corrosion/erosion	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Heating system failure resulting in outlet line freezing	See "Heating System"	N/A	N/A
Tank outlet plugged	TM	Inadvertent outlet control valve closure	Valve inspection (Sec. 9-3.3.1) Response to loss of potable water supply Supervisory alarm response	Weekly/quarterly As necessary As necessary	** As necessary As necessary
	TV	Debris buildup	Main drain test (Section 9-2.6) Response to loss of potable water supply	Quarterly As necessary	Not required As necessary
		Outlet check valve fails open on demand	Main drain test (Section 9-2.6) Check valve inspection (Section 9-4.2.1) Response to loss of potable water supply	Quarterly 5 years As necessary	Not required 5 years As necessary
Tank vent plugged/blocked	TV	Buildup of external debris (e.g., bird nest)	External tank inspection (Section 6-2.2) Tank vent cleaning (Section 6-4.9)	Quarterly Annually	Not required Not required

** - Biweekly if unsupervised AND non-redundant, quarterly if unsupervised AND redundant or supervised AND non-redundant, annually if BOTH supervised AND redundant

Water Supply Components [Gravity Feed Storage Tank (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Internal leak or break of the internal overflow line in a pedestal tank	TL	Corrosion	Internal tank inspection (Section 6-2.4)	3 years/5 years	3 years/5 years
Tank support structure failure	TV	Structure corrosion	External tank inspection (Section 6-2.2)	Quarterly	Not required
		Concrete base deterioration	External tank inspection (Section 6-2.2)	Quarterly	Not required

Water Supply Components [Suction Storage Tank (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Tank external leak/rupture	TV	An embankment type tank rubberized lining puncture/rip resulting in soil embankment erosion	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Corrosion (steel tanks)	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Rot (wooden tanks)	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		An embankment type tank overflow piping plugging resulting in soil embankment erosion	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Mechanical damage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
Outlet line external leak/rupture	TV	Mechanical damage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Corrosion/erosion	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Heating system failure resulting in outlet line freezing	See "Heating System"	N/A	N/A

Water Supply Components [Suction Storage Tank (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Tank outlet plugged	TM	Inadvertent outlet control valve closure	Valve inspection (Section 9-3.3.1) Response to loss of potable water supply Supervisory alarm response	Weekly/quarterly As necessary As necessary	** As necessary As necessary
	TL	Debris buildup	Response to loss of potable water supply	As necessary	As necessary
		Vortex plate loosening and covering the outlet	Response to loss of potable water supply	As necessary	As necessary
		Outlet check valve fails open on demand	Check valve inspection (Section 9-4.2.1) Response to loss of potable water supply	5 years As necessary	5 years As necessary
Overflow line plugged/blocked (embankment type suction tank)	PL	Debris buildup	External tank inspection (Section 6-.2.2) High water level alarm response	Quarterly As necessary	Not required As necessary
		Freezing	See "Heating System".	N/A	N/A
Tank vent plugged	TV	Buildup of external debris (e.g., bird nest)	External tank inspection (Section 6-2.2) Tank vent cleaning (Section 6-4.9)	Quarterly Annually	Not required Not required

** - Biweekly if unsupervised AND non-redundant, quarterly if unsupervised AND redundant or supervised AND non-redundant, annually if BOTH supervised AND redundant

Water Supply Components [Pressure Supply Storage Tank (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Tank external leak/rupture	TV	Mechanical damage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Corrosion	External tank inspection (Section 6-2.2) Internal tank inspection (Section 6-2.4) Low water level alarm response	Quarterly 3 years As necessary	Not required 3 years As necessary
		Tank/air supply system relief valve fails to open on demand or closes prematurely	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Makeup water system relief valve fails to open on demand, closes prematurely or is plugged/blocked	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
Outlet line external leak/rupture	TV	Mechanical damage	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Corrosion/erosion	External tank inspection (Section 6-2.2) Low water level alarm response	Quarterly As necessary	Not required As necessary
		Heating system failure resulting in outlet line freezing	See "Heating System"	N/A	N/A
Tank outlet plugged	TM	Inadvertent closing of the outlet control valve	Main drain test (Section 9-2.6) Valve inspection (Section 9-3.3.1) Supervisory alarm response	Quarterly Weekly/quarterly As necessary	Monthly Monthly As necessary
		Debris buildup	Main drain test (Section 9-2.6)	Quarterly	Monthly
		Outlet check valve fails to open on demand	Main drain test (Section 9-2.6) Check valve inspection (Section 9-4.2.1)	Quarterly 5 years	Monthly 5 years
Drain line external leak/rupture	TV	Mechanical damage	Low water level alarm response	As necessary	As necessary
		Corrosion	Low water level alarm response	As necessary	As necessary

Water Supply Components [Pressure Supply Storage Tank (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Drain valve internal leak	TV	Debris in the valve prevents it from closing	Low water level alarm response	As necessary	As necessary
		Valve seat deterioration or damage	Low water level alarm response	As necessary	As necessary
Tank/air supply system relief valve fails to open on demand	TL	Mechanical damage	External tank inspection (Section 6-2.2)	Quarterly	1 to 2 years
		Damage to internal components resulting in jamming of the valve	No ITM task identified for this failure mode	N/A	N/A
Tank/air supply system relief valve fails to re-seat	TL	Debris in the valve	Response to inability to pressurize tank	As necessary	As necessary
		Internal components damage resulting in the valve jamming	Response to inability to pressurize tank	As necessary	As necessary
		Broken spring	Response to inability to pressurize tank	As necessary	As necessary
Tank/air supply system relief valve opens prematurely	PL	Broken spring	Low air pressure alarm response	As necessary	As necessary
		Improper pressure relief valve setting	Low air pressure alarm response	As necessary	As necessary
Air system supply piping external leak/rupture	TV	Mechanical damage	Low air pressure alarm response	As necessary	As necessary
Makeup water line external leak/rupture	TL	Mechanical damage	Low water level alarm response	As necessary	As necessary
		Corrosion/erosion	Low water level alarm response	As necessary	As necessary

Water Supply Components [Pressure Supply Storage Tank (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Makeup water system relief valve fails to open on demand	TL	Mechanical damage	External tank inspection (Section 6-2.2)	Quarterly	1 to 2 years
		Internal component damage resulting in valve jamming	No ITM task identified for this failure mode	N/A	N/A
		Corrosion	No ITM task identified for this failure mode	N/A	N/A
Makeup system relief valve fails to re-seat	TL	Debris in the valve	Response to inability to pressurize tank	As necessary	As necessary
		Internal component damage resulting in valve jamming	Response to inability to pressurize tank	As necessary	As necessary
		Broken spring	Response to inability to pressurize tank	As necessary	As necessary
Makeup water relief valve opens prematurely	PL	Broken spring	Low water level alarm response	As necessary	As necessary
		Improper pressure relief valve setting	Low water level alarm response	As necessary	As necessary
Air system supply piping plugged/blocked	TL	Debris buildup	Response to inability to pressurize tank	As necessary	As necessary
Makeup water relief valve piping plugged/blocked	TL	External debris buildup	Response to inability to pressurize tank	As necessary	As necessary
Air system fails with no supply	TM	Air system supply valve fails to open while recharging the tank	Response to inability to pressurize tank	As necessary	As necessary
		Air compressor failure	Response to inability to pressurize tank	As necessary	As necessary
		Debris buildup	Response to inability to pressurize tank	As necessary	As necessary

Water Supply Components [Pressure Supply Storage Tank (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Improper supply characteristics from the air system: low pressure	PL	Tank/air supply system relief valve leak	Air pressure inspection (Section 6-2.7)	Monthly/quarterly	1 to 2 years/ Not required
		Premature opening of the tank/air supply system relief valve	Air pressure inspection (Section 6-2.7)	Monthly/quarterly	1 to 2 years/ Not required
		Air supply piping leak	Air pressure inspection (Section 6-2.7)	Monthly/quarterly	1 to 2 years/ Not required
Pressure gauge fails with no reading	TM	Mechanical damage	Pressure gauge test (Section 6-3.6)	5 years	5 years
		Connection plugged	Pressure gauge test (Section 6-3.6)	5 years	5 years
Pressure gauge fails with a high reading	PM	Manual valve inadvertently closed	Pressure gauge test (Section 6-3.6)	5 years	5 years
		Connection plugged	Pressure gauge test (Section 6-3.6)	5 years	5 years
Water level gauge fails with a low reading	PM	Inadvertent closing of the top level gauge manual valve	Level indicator test (Section 6-3.1)	5 years	5 years
		Top connection on the level gauge plugged	Level indicator test (Section 6-3.1)	5 years	5 years
Water level gauge fails with a high reading	TM	Inadvertent closing of the bottom level gauge manual valve	Level indicator test (Section 6-3.1)	5 years	5 years
		Bottom connection on the level gauge plugged	Level indicator test (Section 6-3.1)	5 years	5 years
Water level gauge fails to respond to an input change	PM	Inadvertent closing of the both level gauge manual valves	Level indicator test (Section 6-3.1)	5 years	5 years
		Both connections on the level gauge plugged	Level indicator test (Section 6-3.1)	5 years	5 years

Water Supply Components [Heating Systems (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Heat system fails with no energy input to tank	TM	Loss of utility (i.e., steam, hot water, and/or electricity)	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Loss of water circulation from the tank (e.g., blocked piping, failed pump, closed manual valve)	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Direct injected steam supply line blocked	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Inability to circulate steam/hot water through the heat exchange device (i.e., radiator heater or tank coil)	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Heating controls failure (e.g., thermostat)	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		External rupture of the fire water supply/return piping to/from the heater	See "External Leak/Rupture of Piping to/from the Heater" below	N/A	N/A
External leak/rupture of piping to and from the heating system	PL	Corrosion/erosion	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Mechanical damage	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Freezing due to heating system failure	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary

** - Daily heating system inspections required when temperature is below freezing, no inspections required when a low water temperature alarm is provided

Water Supply Components [Heating Systems (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Improper supply characteristics from the heating system: low temperature	TM	Heating system failure	See "Heating System Fails with No Energy Input to Tank" above.	N/A	N/A
		Steam supply restriction/reduction	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Fouling of heat exchange surfaces	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Temperature controls failure (e.g., thermostat)	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary
		Restricted flow in the heating system circulation loop	Heating system inspection (Section 6-2.8) Response to low water temperature alarm	Daily/weekly As necessary	** As necessary

** - Daily heating system inspections required when temperature is below freezing, no inspections required when a low water temperature alarm is provided

Water Supply Components [Water Makeup Systems (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Water makeup system fails with no supply	PM	Interruption in the supply from the base or public utility company (e.g., line rupture, pump failure)	Water level inspection (Section 6-2.1) Low water level alarm response	Monthly/quarterly As necessary	Semiannually/ 1 to 2 years As necessary
		Inadvertent manual valve closure	Water level inspection (Section 6-2.1) Valve inspection (Section 9-3.3.1) Low water level alarm response Supervisory alarm response	Monthly/quarterly Weekly/monthly As necessary As necessary	Semiannually/ 1 to 2 years ** As necessary As necessary
		Tank level controls failure	Water level inspection (Section 6-2.1)	Monthly/quarterly	Semiannually/ 1 to 2 years
Improper supply characteristics from the water makeup system: low pressure	PV	Reduction in pressure in the base or public utility company supply line	Pressure gauge insp. (Sections 2-2.4.1 and .2) Pressure gauge insp. (Secs 9-4.3.1.1 and .4.1.2)	Weekly/monthly Weekly/monthly	Not required Not required

** - Quarterly if unsupervised AND non-redundant, semiannually if unsupervised AND redundant or supervised AND non-redundant, annually if BOTH supervised AND redundant

Water Supply Components [Centrifugal Fire Pump (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Failure of the jockey pump system to cut off at the desired pressure	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Mechanical damage	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Bearing lubrication/cooling lines leak or rupture	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Pump packing leaks	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Pump casing erosion due to water debris	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Casing cracks due to water in the casing freezing	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Misalignment of the pump shaft and the driver shaft	Pump system inspection (Section 5-2.2) Check pump shaft end play (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
Fails to start	TL	Water in the pump freezes	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Pump shaft seizes	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Pump shaft shears	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Impeller key shears	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually

Water Supply Components [Centrifugal Fire Pump (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fail to start (cont'd)	TL	Debris buildup resulting in an impeller jam	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Coupling failure	Pump churn test (Sections 5-3.2.1 & .2) Check coupling alignment (Section 5-5.1) Lubricate coupling (Section 5-5.1)	Weekly Annually Annually	Semiannually 1 to 2 years 1 to 2 years
		Bearings failure	Pump churn test (Sections 5-3.2.1 & .2) Lubricate bearings (Section 5-5.1)	Weekly Annually	Semiannually Annually
		Gear failure in a right-angle gear box (vertical pump only)	Pump churn test (Sections 5-3.2.1 & .2) Lubricate right-angle gear drive (Section 5-5.1)	Weekly Annually	Semiannually Annually
Fails off while running	TL	Bearing failure from loss of bearing lubrication/cooling	Pump churn test (Sections 5-3.2.1 & .2) Lubricate bearings (Section 5-5.1)	Weekly Annually	Semiannually Annually
		Pump shaft seizure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Impeller key shears	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Debris buildup resulting in an impeller jam	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Coupling failure	Pump churn test (Sections 5-3.2.1 & .2) Check coupling alignment (Section 5-5.1) Lubricate coupling (Section 5-5.1)	Weekly Annually Annually	Semiannually 1 to 2 years 1 to 2 years
		Bearings failure	Pump churn test (Sections 5-3.2.1 & .2) Lubricate bearings (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Gear failure in a right-angle gear box (vertical pump only)	Pump churn test (Sections 5-3.2.1 & .2) Lubricate right-angle gear drive (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years

Water Supply Components [Centrifugal Fire Pump (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Starts prematurely/ operates too long	MM	Spurious start signal from the controller	Response to "Pump Running" signal	As necessary	As necessary
		Inadvertent manual engine start	Response to "Pump Running" signal	As necessary	As necessary
		Inadvertent manual valve closure with the pump running	Response to "Pump Running" signal	As necessary	As necessary
		Jockey pump system external leak/rupture	Response to "Pump Running" signal	As necessary	As necessary
		Failure of jockey pump system to maintain adequate pressure	Response to "Pump Running" signal	As necessary	As necessary
Operates at degraded head/flow	PL	Worn impeller	Pump flow test (Section 5-3.3.1)	Annually	5 years
		Worn casing	Pump flow test (Section 5-3.3.1)	Annually	5 years
		Improper setting of impeller clearances	Pump flow test (Section 5-3.3.1)	Annually	5 years
		Driver operates at degraded rotational speed	Pump flow test (Section 5-3.3.1)	Annually	5 years
External leak/rupture	PL	Corrosion/erosion	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Pump packing leaks	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Pump casing erosion due to water debris	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Casing cracks due to water in the casing freezing	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Misalignment of the pump shaft and the driver shaft	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Failure of the pump relief valve to open on demand or closing prematurely	Circulation relief valve insp. (Section 9-5.4.1)	Weekly	1 to 2 years

Water Supply Components [Jockey Pump System (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails with no supply to the system	PL	Loss of electricity	Supervisory alarm response	As necessary	As necessary
		Motor starter failure	No ITM task identified for this failure mode	N/A	N/A
		Pump driver failure	No ITM task identified for this failure mode	N/A	N/A
		Pump seizure	No ITM task identified for this failure mode	N/A	N/A
		Failure or improper setting of the low pressure cut-in controls	Calibrate pressure switch settings (Sec. 5-5.1) Manual start	Annually As necessary	Not required As necessary
Improper supply characteristics: low pressure	PL	Pump driver failure	Pump churn test (Sections 5-3.2.1 & .2) Pump flow test (Section 5-3.3.1)	Weekly Annually	1 to 2 years 5 years
		Pump seizure	Pump churn test (Sections 5-3.2.1 & .2) Pump flow test (Section 5-3.3.1)	Weekly Annually	1 to 2 years 5 years
		Wearing of the pump impeller	Pump flow test (Section 5-3.3.1)	Annually	5 years
		Increase in pump impeller/casing clearances	Pump flow test (Section 5-3.3.1)	Annually	5 years
		Failure or improper setting of low pressure cut-in controls	Pump flow test (Section 5-3.3.1) Calibrate pressure switch settings (Sec. 5-5.1)	Annually Annually	5 years As necessary
		Loss of electricity	Pump flow test (Section 5-3.3.1)	Annually	5 years
		Motor starter failure	Pump flow test (Section 5-3.3.1)	Annually	5 years
Improper supply characteristics: high pressure	TV	Failure of the high pressure cutoff switch and failure of the pressure relief valve to open	Pump churn test (Section 5-3.2.1 & .2)	Weekly	Annually

Water Supply Components [Pump House Heating System (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to maintain pump house temperature above freezing	PM	Loss of utility (e.g., steam, hot water, electricity)	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Circulation fan failure	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Heating coil failure	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Temperature controls failure	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Inadequate weather seals maintenance	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Excessively low temperature (i.e., lower than design capabilities)	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Manually shut off	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary
		Louvers stuck in the open position	Pump system inspection (Section 5-2.2) Low temperature alarm response	Weekly As necessary	Quarterly* As necessary

* - During winter months

Water Supply Components [Pump House Ventilation System (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to provide pump house circulation	TL	Circulation fan failure	Pump system inspection (Section 5-2.2)	Weekly	Quarterly
		Loss of electricity to the fan	Pump system inspection (Section 5-2.2)	Weekly	Quarterly
		Blocking of louvers in the closed position	Pump system inspection (Section 5-2.2)	Weekly	Quarterly
		Manually turning off the fan	Pump system inspection (Section 5-2.2)	Weekly	Quarterly

Water Supply Components [Diesel Engine Driver for Water Supply Pump (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to start	TL	Loss of fuel supply (including quantity of fuel)	Fuel level inspection (Section 5-5.1)	Weekly	Semiannually and after actuation
		Fails to receive the start signal from the controller	Pump flow test (Section 5-3.3.1)	Annually	**
		Low pump house temperature	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
		Electric starter motor failure	Pump flow test (Section 5-3.3.1)	Annually	1 to 2 years

** - Annually if a single pump, 5 yrs if redundant

Water Supply Components [Diesel Engine Driver for Water Supply Pump (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
Fails to start (cont'd)	TL	Weak battery	Pump system inspection (Section 5-2.2) Battery check (Section 5-5.1)	Weekly Monthly	Semiannually Semiannually
		Hydraulic starter failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Engine ignition system failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Engine exhaust system plugs	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Air-supplied motor starter failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Wet fuel	Pump churn test (Sections 5-3.2.1 & .2) Fuel quality inspection (Section 5-5.1)	Weekly Weekly	Semiannually Semiannually
		Fuel pump failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Plugging of the engine air intake	Pump system inspection (Section 5-2.2)	Weekly	Semiannually
Fails off while running	TL	Engine ignition system failure	No ITM task identified for this failure mode	N/A	N/A
		Engine seizure due to engine lubrication system failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Failure due to loss of engine cooling	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Loss of fuel supply (including quantity of fuel)	Fuel level inspection (Section 5-5.1)	Weekly	Semiannually
		Plugging of the engine exhaust system	No ITM task associated with this failure mode	N/A	N/A
		Plugging of the engine air intake	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Overspeed protection device failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Wet fuel	Fuel quality inspection (Section 5-5.1)	Weekly	Semiannually

Water Supply Components [Diesel Engine Driver for Water Supply Pump (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
Fails off while running (cont'd)	TL	Fuel pump failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Operation of the engine at elevated rotational speed	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
Starts prematurely/ operates too long	MM	Spurious start signal from the controller	Response to "Pump Running" signal	As necessary	As necessary
		Inadvertent manual starting of the engine	Response to "Pump Running" signal	As necessary	As necessary
		Inadvertent closing of a manual isolation valve with the pump running	Response to "Pump Running" signal	As necessary	As necessary
Starts too late	PV	Failure of a controller automatic start circuit that requires the driver to manually be started	Pump flow test (Section 5-3.3.1)	Annually	Not required
Operates at degraded torque/rotational speed performance	PL	Throttle control failure	Pump flow test (Section 5-3.3.1)	Annually	Not required
		Inadequate ventilation	Pump flow test (Section 5-3.3.1)	Annually	Not required
		Sticking of the throttle	Pump flow test (Section 5-3.3.1)	Annually	Not required
Operates at an elevated torque/rotational speed	TL	Overspeed protection device failure	Pump churn test (Section 5-3.2.1 & .2)	Weekly	Semiannually
		Throttle controls failure	Pump churn test (Section 5-3.2.1 & .2)	Weekly	Semiannually

Water Supply Components [Electric Motor Driver (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to start	TV	Loss of electricity	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years
		Motor starter circuit failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years
		Degradation of the motor windings	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years
		Open (e.g., loose connection) or short circuit in the motor leads	Pump churn test (Sections 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	1 to 2 years Not required
		Blown fuse	Pump churn test (Sections 5-3.2.1 & .2) Fuse inspection (Section 5-5.1) Fuse replacement (Section 5-5.1)	Weekly Monthly Biannually	1 to 2 years 1 to 2 years Not required
Fails off while running	TL	Loss of electricity	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Motor starter circuit failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Degradation of the motor windings	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Open (e.g., loose connection) or short circuit in the motor leads	Pump churn test (Sections 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Blown fuse	Pump churn test (Sections 5-3.2.1 & .2) Fuse inspection (Section 5-5.1) Fuse replacement (Section 5-5.1)	Weekly Monthly Biannually	Semiannually Semiannually 1 to 2 years
		Poor air circulation in the motor resulting in overheating of the motor and tripping of the thermal overloads	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually

Water Supply Components [Electric Motor Driver (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Starts prematurely/ operates too long	MM	Spurious start signal from the controller	Response to "Pump Running" signal	As necessary	As necessary
		Inadvertent manual starting of the engine	Response to "Pump Running" signal	As necessary	As necessary
		Inadvertent closing of a manual isolation valve with the pump running	Response to "Pump Running" signal	As necessary	As necessary
Starts too late	PV	Controller automatic start circuit failure resulting in the driver needing to be started manually	Pump churn test (Section 5-3.3.1)	Weekly	Semiannually

Water Supply Components [Electric Supply System for Pump Drivers (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails with no supply	TL	Loss of supply from the utility company	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Failure of the service disconnect	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Open (e.g., loose connection) or short circuit in leads to the motor starter	Pump churn test (Sections 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Service transformer failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Blown fuse	Pump churn test (Sections 5-3.2.1 & .2) Fuse inspection (Section 5-5.1) Fuse replacement (Section 5-5.1)	Weekly Monthly Biannually	Semiannually Semiannually 1 to 2 years
Improper supply characteristics: low voltage	TV	Step-down transformer failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years
		Loss of a power leg	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years

Water Supply Components [Fuel Supply System for Pump Drivers (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture in the system	TV	Damage to the fuel tank during filling (e.g., filling without tank venting)	Pump system inspection (Section 5-2.2) Fuel level inspection (Section 5-5.1) Low fuel level alarm response	Weekly Weekly As necessary	1 to 2 years 1 to 2 years As necessary
		Mechanical damage to the fuel lines	Pump system inspection (Section 5-2.2) Fuel level inspection (Section 5-5.1) Low fuel level alarm response	Weekly Weekly As necessary	1 to 2 years 1 to 2 years As necessary
		Deterioration of the flexible connectors	Pump system inspection (Section 5-2.2) Fuel level inspection (Section 5-5.1) Low fuel level alarm response	Weekly Weekly As necessary	1 to 2 years 1 to 2 years As necessary
		Inadvertent opening of the tank drain valve	Pump system inspection (Section 5-2.2) Fuel level inspection (Section 5-5.1) Low fuel level alarm response	Weekly Weekly As necessary	1 to 2 years 1 to 2 years As necessary
Fails with no supply to the diesel engine	TL	Sludge buildup in the fuel line	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Inadvertent closing of a manual valve in the fuel line	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Plugging of the fuel filter	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Failure of the fuel solenoid valve to open	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Plugging of the tank vent	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Fuel pump failure	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Insufficient quantity of fuel in the tank	See "Improper Supply Characteristics: Low Fuel Quantity" below.	N/A	N/A

Water Supply Components [Fuel Supply System for Pump Drivers (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Improper supply characteristics: low fuel quantity	TL	External leak/rupture of the fuel system	See "External Leak/Rupture in the System" above.	N/A	N/A
		Running of the driver for testing (without means to ensure the fuel tank is refilled)	Pump system inspection (Section 5-2.2) Fuel level inspection (Section 5-5.1) Low fuel level alarm response	Weekly Weekly As necessary	Semiannually Semiannually As necessary
		Inaccurate or improper operation of the fuel level gauge	Pump system inspection (Section 5-2.2) Fuel level inspection (Section 5-5.1) Low fuel level alarm response	Weekly Weekly As necessary	Semiannually Semiannually As necessary

Water Supply Components [Controller for Pump Drivers (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to respond to an input (initiating signal) change (i.e., loss of water pressure on system-side water line pressure switch)	TL	Failure of the pressure switch or its signal wiring	Pump churn test (Section 5-3.2.1 & .2) Pressure switch setting inspection (Sec. 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Loss of connection	Pump churn test (Section 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Loss of electricity (electric pressure switch)	Pump churn test (Section 5-3.2.1 & .2)	Weekly	Semiannually
		Weak battery (diesel driver)	Pump churn test (Section 5-3.2.1 & .2) Battery check (Section 5-5.1)	Weekly Monthly	Semiannually Semiannually
		Plugging of the pressure switch connection	Pump churn test (Section 5-3.2.1 & .2)	Weekly	Semiannually

Water Supply Components [Controller for Pump Drivers (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Electric motor starter contactor fails to make or fails off while running	TL	Loose wiring connection	Pump churn test (Sections 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Low supply voltage	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Opening of the normal power isolation switch	Pump churn test (Sections 5-3.2.1 & .2) Isolation switch operation (Section 5-5.1)	Weekly Monthly	Semiannually Semiannually
		Worn/dirty contacts on the starter relay	Pump churn test (Sections 5-3.2.1 & .2) Manual start operation (Section 5-5.1)	Weekly Semiannually	Semiannually 1 to 2 years
		Tripping of circuit breaker	Pump churn test (Sections 5-3.2.1 & .2) Circuit breaker operation (Section 5-5.1) Circuit breaker inspection (Section 5-5.1)	Weekly Monthly Annually	Semiannually Semiannually 1 to 2 years
Diesel engine motor starter circuit fails to make connection	TL	Loose wiring connection	Pump churn test (Sections 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Worn/dirty contacts on the starter relay	Pump churn test (Sections 5-3.2.1 & .2) Manual start operation (Section 5-5.1)	Weekly Semiannually	Semiannually 1 to 2 years
		Tripping of circuit breaker	Pump churn test (Sections 5-3.2.1 & .2) Circuit breaker operation (Section 5-5.1) Circuit breaker inspection (Section 5-5.1)	Weekly Monthly Annually	Semiannually Semiannually 1 to 2 years
		Low supply voltage	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
Diesel engine motor starter circuit fails to disengage after engine starts	ML	Motor starter circuit sticking	"Pump running" alarm response	As necessary	As necessary
Emergency power transfer switch fails to make connection	TL	Fusing or sticking of the contacts in the normal power switch	Emergency power test (Section 5-5.1)	Annually	1 to 2 years
		Worn/dirty contacts in the emergency power switch	Emergency power test (Section 5-5.1)	Annually	1 to 2 years
		Failure of a timer circuit in the emergency power switch	Emergency power test (Section 5-5.1)	Annually	1 to 2 years
		Failure of the alternate source voltage/frequency sensing device	Emergency power test (Section 5-5.1)	Annually	1 to 2 years

Water Supply Components [Controller for Pump Drivers (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Controller fails to send output signals (i.e., run status and supervisory)	PM	Loose wiring connection	Pump churn test (Sections 5-3.2.1 & .2) Connection inspection (Section 5-5.1)	Weekly Annually	Semiannually 1 to 2 years
		Corrosion of contacts	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Indicator failure (e.g., burnt out bulb)	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Loss of control power	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Normal power isolation switch is open	Pump churn test (Sections 5-3.2.1 & .2) Isolation switch operation (Section 5-5.1)	Weekly Monthly	Semiannually Semiannually
		Tripping of circuit breaker	Pump churn test (Sections 5-3.2.1 & .2) Circuit breaker operation (Section 5-5.1) Circuit breaker inspection (Section 5-5.1)	Weekly Monthly Annually	Semiannually Semiannually 1 to 2 years

Water Supply Components [Suction Piping and Valves (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Corrosion/erosion	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
Plugged/blocked	TM	Debris buildup	No ITM task associated with this failure mode	N/A	N/A
		Inadvertent closure of a manual valve	Valve inspection (Section 9-3.3.1) Supervisory alarm response	Weekly/monthly As necessary	** As necessary
Spurious position of a valve	PM	Valve not fully opened due to human error	Pump system inspection (Section 5-2.2) Valve inspection (Section 9-3.3.1)	Weekly Weekly/monthly	Monthly **
		Separation of gate and stem	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Debris jamming the valve	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Galling of valve surfaces at the gate and slide guides	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
Valve fails to open	TL	Valve inadvertently left close	Valve inspection (Section 9-3.3.1)	Weekly/monthly	**
		Separation of gate and stem	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Debris jamming the valve	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Galling of valve surfaces at the gate and slide guides	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years

** - Unsupervised valve/quarterly; supervised valve/annually

Water Supply Components [Discharge Piping and Valves (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
		Corrosion/erosion	Pump system inspection (Section 5-2.2)	Weekly	1 to 2 years
Plugged/blocked	TM	Inadvertent closure of a manual valve	Valve inspection (Section 9-3.3.1) Supervisory alarm response	Weekly/monthly As necessary	** As necessary
Spurious position of a valve	TL	Valve not fully opened due to human error	Pump system inspection (Section 5-2.2) Valve inspection (Section 9-3.3.1)	Weekly Weekly/monthly	Monthly **
		Separation of gate and stem	Valve operation (Section 9-3.4.2)	Annually	Semiannually
		Debris jamming the valve	Valve operation (Section 9-3.4.2)	Annually	Semiannually
		Galling of valve surfaces at the gate and slide guides	Valve operation (Section 9-3.4.2)	Annually	Semiannually
Valve fails to open	PM	Valve inadvertently left close	Valve inspection (Section 9-3.3.1)	Weekly/monthly	**
		Separation of gate and stem	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Debris jamming the valve	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Galling of valve surfaces at the gate and slide guides	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years

** - Unsupervised valve/quarterly; supervised valve/annually

Water Supply Components [Discharge Piping and Valves (NFPA 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Pressure relief valve (PRV) fails to open on demand	TL	Mechanical damage that results in a jam of the valve stem/guide	PRV inspection (Section 9-5.4.2)	Weekly	Semiannually
Pressure relief valve fails to re-seat	PL	Broken spring that results in jamming the valve open	PRV inspection (Section 9-5.4.2)	Weekly	1 to 2 years
		Debris buildup at the valve seat	PRV inspection (Section 9-5.4.2)	Weekly	1 to 2 years
		Mechanical damage to the valve guide	PRV inspection (Section 9-5.4.2)	Weekly	1 to 2 years
Pressure relief valve open prematurely	PM	Broken/weak spring	PRV test (Section 9-5.4.2.2)	Annually	1 to 2 years
		Improper relief pressure setting	PRV test (Section 9-5.4.2.2)	Annually	1 to 2 years
Check valve fails to open on demand	TL	Debris buildup	Pump flow test (Section 5-3.3.1)	Annually	1 to 2 years
		Corrosion	Pump flow test (Section 5-3.3.1)	Annually	1 to 2 years
Check valve fails to close on demand	TL	Debris buildup	Check valve interior inspection (Sec. 9-4.2.1)	5 years	5 years
		Corrosion	Check valve interior inspection (Sec. 9-4.2.1)	5 years	5 years

Water Supply Components [Fire Pump Circulation Relief Valve (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	MV	Corrosion/erosion of the piping	Circulation relief valve insp. (Section 9-5.4.1)	Weekly	Not required
		Vibration	Circulation relief valve insp. (Section 9-5.4.1)	Weekly	Not required
		Mechanical damage	Circulation relief valve insp. (Section 9-5.4.1)	Weekly	Not required
Fails to open on demand	PL	Debris buildup	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years
		Mechanical damage that results in a valve stem/guide jam	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	1 to 2 years

Water Supply Components [Fire Pump Air Relief Valve (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	MV	Mechanical damage	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Not required
Plugged/blocked	TL	Debris buildup	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Corrosion	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Freezing	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
Fails to open	TL	Sticking of the valve internals	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Debris buildup	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Corrosion	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually
		Freezing	Pump churn test (Sections 5-3.2.1 & .2)	Weekly	Semiannually

Water Supply Components [Fire Hydrant Valve (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Internal leak (dry barrel only)	TL	Valve seat damage or deterioration	Hydrant inspection (Section 4-2.2.5)	Annually	1 to 2 years
Fails to open	TL	Separation of the valve stem from the valve plate	Hydrant flow test (Section 4-3.2) Valve operation (Section 9-3.4.2)	Annually Annually	1 to 2 years 1 to 2 years
		Separation of the valve stem from the upper stem	Hydrant flow test (Section 4-3.2) Valve operation (Section 9-3.4.2)	Annually Annually	1 to 2 years 1 to 2 years
		Rusting	Hydrant flow test (Section 4-3.2) Valve lubrication (Section 4-4.3.1) Valve operation (Section 9-3.4.2)	Annually Annually Annually	1 to 2 years 1 to 2 years 1 to 2 years
		Jamming of the valve plate due to debris above the valve	Hydrant flow test (Section 4-3.2) Valve operation (Section 9-3.4.2)	Annually Annually	1 to 2 years 1 to 2 years
Spurious position	PL	Separation of the valve stem from the valve plate	Hydrant flow test (Section 4-3.2) Valve operation (Section 9-3.4.2)	Annually Annually	Not required Not required
		Separation of the valve stem from the upper stem	Hydrant flow test (Section 4-3.2) Valve operation (Section 9-3.4.2)	Annually Annually	Not required Not required
		Jamming of the valve plate due to debris above the valve	Hydrant flow test (Section 4-3.2) Valve operation (Section 9-3.4.2)	Annually Annually	Not required Not required

Water Supply Components [Fire Hydrant Barrel (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Hydrant inspection (Sections 4-2.2.4 & .5)	Annually	1 to 2 years
		Freezing	Hydrant inspection (Section 4-2.2.4)	Annually	1 to 2 years
Plugged/blocked	TL	Freezing	Hydrant flow test (Section 4-3.2)	Annually	1 to 2 years
Damaged hose outlets	PL	Mechanical damage	Hydrant inspection (Sections 4-2.2.4 & .5)	Annually	Not required
		Cross-threading when reinstalling hydrant caps or connecting a hose	Hydrant inspection (Sections 4-2.2.4 & .5)	Annually	Not required

Water Supply Components [Fire Hydrant Drain (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Plugged/blocked	TL	Debris buildup	Hydrant inspection (Section 4-2.2.4)	Annually	1 to 2 years

Water Supply Components [Fire Hydrant Connection Valve (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	Visual grounds inspection	N/A	N/A
		Freezing	Visual grounds inspection	N/A	N/A
Fails to open	TV	Separation of stem and valve gate	Valve operation (Section 9-3.4.2)	Annually	Not required
		Rounded off stem/reach rod connection	Valve operation (Section 9-3.4.2)	Annually	Not required
Spurious position	PM	Separation of stem and valve gate	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Jamming of the gate valve	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years
		Valve not completely opened	Valve operation (Section 9-3.4.2)	Annually	1 to 2 years

Water Supply Components [Fire Hydrant Water Supply Line (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Visual grounds inspection	N/A	N/A
		Corrosion/erosion	Visual grounds inspection	N/A	N/A
		Freezing	Visual grounds inspection	N/A	N/A
		Damaged or missing thrust block	Visual grounds inspection	N/A	N/A

Foam and Foam-water Systems [Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Corrosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Freezing	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Proportioner plugged/blocked	TL	Foam concentrate buildup and solidification due to improper flushing after discharge	Full flow test (Section 8-3.3) Proper flushing after actuation	Annually As necessary	1 to 2 years As necessary
		Strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2) Full flow test (Section 8-3.3)	Quarterly Annually	Annually 1 to 2 years
		Internal leak in the concentrate control valve	Full flow test (Section 8-3.3)	Annually	1 to 2 years
External leak/rupture of the proportioner foam concentrate inlet	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Corrosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Foam concentrate supply line vibrations	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Foam concentrate inlet plugged/blocked	TL	Foam concentrate buildup and solidification due to improper flushing after discharge	Full flow test (Section 8-3.3) Proper flushing after actuation	Annually As necessary	Semiannually As necessary
		Strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2) Full flow test (Section 8-3.3)	Quarterly Annually	Annually 1 to 2 years
		Corrosion	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Foam and Foam-water Systems [Proportioner Water Supply Piping (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Corrosion/erosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Freezing	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Plugged/blocked	TV	Debris buildup	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Foam and Foam-water Systems [Foam Concentrate Supply Piping (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Corrosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Vibration	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Plugged/blocked	TL	Inadvertent closing of manual valve	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Foam concentrate buildup and solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate gelling/solidification at low ambient temperatures	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Corrosion	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Foam and Foam-water Systems [Proportioner Discharge Piping (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
		Corrosion/erosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
Plugged/blocked	TL	Freezing	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Debris buildup	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Pipe scale buildup	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Foam and Foam-water Systems [Concentrate Storage Tank Fill Piping (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PV	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Not required
		Manual fill valve inadvertently left open or leaking through	Proportioning system inspection (Sec. 8-2.11)	Monthly	Not required

Foam and Foam-water Systems [Concentrate Recycle Piping (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Corrosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Manual drain in recycle line inadvertently left open or leaks through	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Plugged/blocked	PM	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2) Full flow test (Section 8-3.3)	Quarterly Annually	1 to 2 years 1 to 2 years
		Inadvertent manual valve closure	Proportioning system inspection (Sec. 8-2.11) Full flow test (Section 8-3.3)	Monthly Annually	Semiannually 1 to 2 years

Foam and Foam-water Systems [Foam Concentrate Storage Bladder Tank (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Tank shell external leak/rupture	TL	Corrosion	Proportioning system insp. (Section 8-2.11.3.2) Hydrostatic test (Section 8-4.2b)	Monthly 10 years	Semiannually 10 years
Shell water inlet plugged/blocked	TM	Debris buildup	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Strainer plugged	Strainer inspection (Section 8-2.9.2) Full flow test (Section 8-3.3)	Quarterly Annually	Annually 1 to 2 years
		Inadvertent closure of manual inlet valve	Proportioning system insp. (Section 8-2.11.3.2) Full flow test (Section 8-3.3)	Monthly Annually	Semiannually 1 to 2 years
Shell vent valve internally leaks or left open	PM	Inadvertently left open	Proportioning system insp. (Section 8-2.11.3.2)	Monthly	Semiannually
		Valve seal/seat damage or deterioration	Hydrostatic test (Section 8-4.2b)	10 years	10 years
Shell drain valve and/or drain nozzle plugged	ML	Debris buildup	Response to improper drainage	As necessary	As necessary
Shell drain valve internally leaks	TM	Inadvertently left open	Proportioning system insp. (Section 8-2.11.3.2)	Monthly Annually	Semiannually 1 to 2 years
		Valve seal/seat damage or deterioration	Full flow test (Section 8-3.3) Hydrostatic test (Section 8-4.2b)	Annually 10 years	1 to 2 years 10 years
Bladder leak/rupture	TL	Debris punctures bladder during fill	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Improper filling (e.g., overpressurizing or filling)	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Bladder deterioration (i.e., due to bladder aging)	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Bladder outlet valve plugged	TL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Bladder vent valve internally leaks or left open	PM	Inadvertently left open	Proportioning system insp. (Section 8-2.11.3.2)	Monthly	Semiannually
		Valve seat/seals damage or deterioration	Hydrostatic test (Section 8-4.2b)	10 years	10 years

Foam and Foam-water Systems [Foam Concentrate Storage Atmospheric Tank (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
		Corrosion	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
		Failure of the pressure/vacuum device during filling or emptying resulting in tank pressurization	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
Outlet nozzle plugged/blocked	TL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Recycle inlet plugged/blocked	PM	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Inadvertent closing of the inlet manual valve	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Drain line external leak/rupture	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Drain valve internally leaks or left open	TL	Inadvertently left open	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Valve seat/seals deterioration or damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Vent plugged/blocked	PL	Physical obstruction	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
		Foam concentrate buildup and solidification	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years

Foam and Foam-water Systems [Foam Concentrate Storage Pressure Vessel (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Corrosion	Proportioning system inspection (Sec. 8-2.11) Hydrostatic test (Section 8-4.1c) Tank corrosion inspection (Section 8-4.1c)	Monthly 10 years 10 years	1 to 2 years 10 years 10 years
		Mechanical damage	Proportioning system inspection (Sec. 8-2.11) Hydrostatic test (Section 8-4.1c) Tank corrosion inspection (Section 8-4.1c)	Monthly 10 years 10 years	1 to 2 years 10 years 10 years
Drain line external leak/rupture	TV	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	1 to 2 years
Tank drain valve internally leaks or left open	TL	Inadvertently left open	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semimonthly
		Debris in the valve prevents complete closure	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semimonthly
		Valve seat/seals damage or deterioration	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semimonthly
		Mechanical damage	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semimonthly
Tank drain valve and/or nozzle plugged	ML	Foam concentrate buildup and solidification	Verification of proper refilling	As necessary	As necessary
PPH operating head plugged blocked	TL	Water supply line strainer failure resulting in debris buildup	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate buildup and solidification	Full flow test (Section 8-3.3) Proper flushing after actuation	Annually As necessary	1 to 2 years As necessary

Foam and Foam-water Systems [Foam Concentrate Storage Pressure Vessel (NFPA 11, 11A and 25)] cont'd

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Tank fill port or inspection/fill vent externally leaking or left open	PM	Cap inadvertently left off after filling/inspecting the tank	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Cap not properly tightened	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Concentrate fill nozzle/valve plugged	ML	Buildup of foam concentrate	Verification of proper refilling	As necessary	As necessary
Inspection fill vent port plugged/blocked	PM	Failure or inability (e.g., cap cross-threaded) to remove cap during tank refilling	Verification of proper refilling	As necessary	As necessary

Foam and Foam-water Systems [Actuated Control Valves (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Leaking stem seals	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Leaking bonnet gaskets	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Internal leak	TL	Worn seat	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Valve ball scoring	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Debris preventing the valve from completely closing	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Plugged/blocked	TL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3) Proper flushing after actuation	Annually As necessary	1 to 2 years As necessary
Fails to open	TL (electric)	Solenoid fails to receive the open signal	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Failure of the solenoid to change state	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Failure of the actuator to change position	Full flow test (Section 8-3.3)	Annually	1 to 2 years/ Monthly
	TM (hydraulic)	Loss of water pressure in the signal line due to a closed isolation valve in the line or line is plugged/blocked	Provide valve supervision (if no supervision, provide valve inspection)	Monthly	Monthly
	TV	Separation of the valve ball from the valve stem	Full flow test (Section 8-3.3)	Annually	Not required
		Separation of the valve stem from the actuator	Full flow test (Section 8-3.3)	Annually	Not required
		Seizing of the valve ball to the valve body	Full flow test (Section 8-3.3)	Annually	Not required

Foam and Foam-water Systems [Actuated Control Valves (NFPA 11, 11A and 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to close	TL (electric) TM (hydraulic)	Improper resetting of a hydraulic actuator	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Monthly
		Actuator failure	Full flow test (Section 8-3.3)	Annually	Semiannually/ 1 to 2 years
		Separation of the valve ball from the valve stem	Full flow test (Section 8-3.3)	Annually	Semiannually/ 1 to 2 years
		Separation of the valve stem from the actuator	Full flow test (Section 8-3.3)	Annually	Semiannually/ 1 to 2 years
		Seizing of the valve ball to the valve body	Full flow test (Section 8-3.3)	Annually	Semiannually/ 1 to 2 years
Spurious position	PL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3)	Annually	Not required
		Concentrate supply line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Monthly	1 to 2 years
		Seizing of the valve ball to the valve body	Full flow test (Section 8-3.3)	Annually	Not required
Opens prematurely	TL	Spurious actuation signal	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semiannually
		Loss of power to the solenoid	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semiannually

Foam and Foam-water Systems [Non-actuated Concentrate Control Valves (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Leaking stem seals	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
		Leaking bonnet gaskets	Proportioning system inspection (Sec. 8-2.11)	Monthly	Semiannually
Internal leak	TL	Worn seat	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Valve ball scoring	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Debris preventing the valve from completely closing	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Plugged/blocked	TL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3) Proper flushing after actuation	Annually As necessary	1 to 2 years As necessary
Fails to open (NC)	TL	Separation of the valve ball from the valve stem	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Seizing of the valve ball to the valve body	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Fails to close (manual)	TL	Inadvertently left open	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semiannually
		Stem/ball separation	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Seizing of the valve ball to the valve body	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Spurious position	PL	Incorrectly positioned (i.e., not fully open) when opening the valve	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	1 to 2 years
		Seizing of the valve ball to the valve body	Full flow test (Section 8-3.3)	Annually	Not required

Foam and Foam-water Systems [Foam Concentrate Pump for a Standard Balance Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
		Failure of the pump seal packing	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
		Overpressure due to the pump running deadheaded	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
Fails to start	TL	Failure of the motor (or driver)	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
		Breaking of the driver/pump coupling	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
		Failure in the motor control circuit	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
		Motor controller fails to receive the start signal	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
Fails off while running	TL	Failure of the motor (or driver)	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
		Breaking of the driver/pump coupling	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
		Failure in the motor control circuit	Concentrate pump operation (Section 8-4.4)	Monthly	Semiannually
Starts prematurely/ operates too long	TL	Spurious start signal from the motor controller	No ITM task associated with failure mode	N/A	N/A
		Pump inadvertently started manually	No ITM task associated with failure mode	N/A	N/A
Operates at degraded head/flow	PV	Worn gears or casing	Concentrate pump operation (Section 8-4.4)	Monthly	Not required

Foam and Foam-water Systems [Foam Concentrate Pump for an In-line Balanced Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Pump seal packing failure	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Overpressure due to the pump running deadheaded	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
Fails to start	TL	Motor/driver failure	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
		Breaking of the driver/pump coupling	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
		Motor control circuit failure	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
		Motor controller fails to receive the start signal	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
Fails off while running	TL	Motor/driver failure	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
		Breaking of the driver/pump coupling	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
		Failure in the motor control circuit	Concentrate pump operation (Section 8-4.5)	Monthly	Semiannually
Starts prematurely/ operates too long	TL	Spurious start signal from the motor controller	No ITM task associated with failure mode	N/A	N/A
		Pump inadvertently started manually	No ITM task associated with failure mode	N/A	N/A
Operates at degraded head/flow	PV	Worn gears or casing	Concentrate pump operation (Section 8-4.5)	Monthly	Not required

Foam and Foam-water Systems [Concentrate P Sensing Line for a Standard Balance Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	1 to 2 years
		Corrosion	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	1 to 2 years
Plugged/blocked	PM	Solidification of improperly drained foam concentrate	Full flow test (Section 8-3.3) Proper drainage after actuation	Annually	1 to 2 years
		Inadvertent closure of the manual valve	Proportioning system inspection (Sec. 8-2.11.1)	Monthly	Semiannually
		Concentrate supply line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Quarterly	1 to 2 years

Foam and Foam-water Systems [Automatic Balancing Valve for a Standard Balance Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
		Corrosion	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
		Valve stem/bonnet seals deterioration	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
Internal leak	TL	Worn seat	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Actuator fails to develop/exert sufficient closing force to completely close the valve	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Plugged/blocked	PL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Annually 5 years	Not required 5 years
		Foam concentrate supply line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Quarterly	Not required
Fails to open	PM	Foam concentrate pressure sensing line external rupture	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
		Separation of the valve disk from the valve stem	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate buildup and solidification at the valve seat	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Annually 5 years	1 to 2 years 5 years
		Valve actuator diaphragm rupture	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Inadvertent closing of the foam concentrate pressure sensing line isolation valve	Proportioning system insp. (Sec. 8-2.11.3.4)	Monthly	Semiannually

Foam and Foam-water Systems [Automatic Balancing Valve for a Standard Balance Pressure Proportioner (NFPA 11, 11A and 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to close	PM	Water pressure sensing line external rupture	Piping inspection (Section 8-2.3) Proportioning system insp. (Section 8-2.11.3.4) Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Quarterly Monthly Annually 5 years	1 to 2 years semiannually 1 to 2 years 5 years
		Separation of the valve disk from the valve stem	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Annually 5 years	1 to 2 years 5 years
		Inadvertent closing of the water pressure sensing line isolation valve	Proportioning system insp. (Section 8-2.11.3.4) Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Monthly Annually 5 years	Semiannually 1 to 2 years 5 years
		Valve actuator spring failure	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Annually 5 years	1 to 2 years 5 years
		Separation of the valve stem from the valve actuator	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.4c)	Annually 5 years	1 to 2 years 5 years
Spurious position	PL	Leakage in either pressure sensing line	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	1 to 2 years
Opens prematurely	TL	Valve actuator spring failure	No ITM task associated with this failure mode	N/A	N/A
		Water pressure sensing line external rupture	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
Closes prematurely	PL	Valve actuator diaphragm rupture	No ITM task associated with this failure mode	N/A	N/A
		Foam concentrate pressure sensing line external rupture	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	1 to 2 years

Foam and Foam-water Systems [Diaphragm Balancing Valve for an In-line Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Leaking stem seals	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Leaking bonnet gaskets	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
Plugged	TL	Foam concentrate buildup and solidification	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.5c)	Annually 5 years	1 to 2 years 5 years
		Foam concentrate supply line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Quarterly	1 to 2 years
Fails to open	TL	Foam concentrate pressure sensing line external rupture	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Separation of the valve stem from the actuator	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Separation of the valve ball from the valve stem	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate buildup and solidification at the valve seat	Full flow test (Section 8-3.3) Balancing valve flushing (Section 8-4.5c)	Annually 5 years	1 to 2 years 5 years
		Valve diaphragm rupture	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Inadvertent closing of the foam concentrate pressure sensing line isolation valve	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually

Foam and Foam-water Systems [Diaphragm Balancing Valve for an In-line Pressure Proportioner (NFPA 11, 11A and 25)] continued

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to close	PM	Water pressure sensing line external rupture	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Separation of the valve disk from the valve stem	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Inadvertent closing of the water pressure sensing line isolation valve	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Valve actuator spring failure	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Separation of the valve ball from the valve stem	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Separation of the valve stem from the valve actuator	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Spurious position	PL	Leakage in either pressure sensing line	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	1 to 2 years
Closes prematurely	TL	Valve actuator diaphragm rupture	Full flow test (Section 8-.3.3)	Annually	1 to 2 years
		Foam concentrate pressure sensing line external rupture	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually

Foam and Foam-water Systems [Concentrate P Sensing Line for an In-line Balanced Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	1 to 2 years
		Corrosion	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	1 to 2 years
Plugged/blocked	PM	Solidification of improperly drained foam concentrate	Full flow test (Section 8-3.3) Proper drainage after actuation	Annually As necessary	1 to 2 years As necessary
		Inadvertent manual valve closure	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Concentrate supply line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Quarterly	1 to 2 years

Foam and Foam-water Systems [Water P Sensing Line for a Standard Balance Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	1 to 2 years
		Corrosion	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	1 to 2 years
Plugged/blocked	PM	Inadvertent isolation valve closure	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually

Foam and Foam-water Systems [Water Pressure Sensing Line for an In-line Balanced Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PV	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Not required
		Corrosion	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Not required
Plugged/blocked	PM	Inadvertent isolation valve closure	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually

Foam and Foam-water Systems [Pump Pressure Relief Valve for a Standard Balance Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
		Inlet/outlet piping corrosion	Proportioning system insp. (Section 8-2.11.3.4)	Monthly	Semiannually
Plugged/blocked	TL	Foam concentrate solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Monthly	Semiannually
Fails to open upon demand	TL	Foam concentrate solidification above and below the valve disk	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Internal/external mechanical damage the results in a jamming of the valve stem/guide	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Fails to re-seat	PL	Broken spring that results in a jammed open valve	Full flow test (Section 8-3.3)	Annually	Not required
		Debris buildup or foam concentrate solidification at the valve seat	Full flow test (Section 8-3.3)	Annually	Not required
		Valve guide mechanical damage	Full flow test (Section 8-3.3)	Annually	Not required
Opens prematurely	PM	Broken/weak spring	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Improper relief valve pressure setting	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Foam and Foam-water Systems [Pump Pressure Relief Valve for an In-line Balanced Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
		Inlet/outlet piping corrosion	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
Plugged	TL	Foam concentrate solidification	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Foam concentrate line strainer failure resulting in debris buildup	Strainer inspection (Section 8-2.9.2)	Monthly	Semiannually
Fails to open upon demand	TL	Foam concentrate solidification above and below the valve disk	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Internal/external mechanical damage the results in a jamming of the valve stem/guide	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Fails to re-seat	PL	Broken spring that results in a jammed open valve	Full flow test (Section 8-3.3)	Annually	Not required
		Debris buildup or foam concentrate solidification at the valve seat	Full flow test (Section 8-3.3)	Annually	Not required
		Valve guide mechanical damage	Full flow test (Section 8-3.3)	Annually	Not required
Opens prematurely	PM	Broken/weak spring	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Improper relief valve pressure setting	Full flow test (Section 8-3.3)	Annually	1 to 2 years

Foam and Foam-water Systems [Pressure Regulating Valve for an In-line Balanced Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.5)	Monthly	Semiannually
Fails with low pump discharge pressure	TM	Improper adjustment	Full flow test (Section 8-3.3)	Annually	
		Valve internals (e.g., valve seat and stem) jam and stick	Full flow test (Section 8-3.3)	Annually	

Foam and Foam-water Systems [Ball Drip Valve for a Standard Pressure Proportioner (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	ML	Mechanical damage	Proportioning system insp. (Section 8-2.11.3.1)	Monthly	Not required
		Ball seal damage or deterioration	Proportioning system insp. (Section 8-2.11.3.1)	Monthly	Not required
Plugged/blocked	PL	Debris buildup	Proportioning system insp. (Section 8-2.11.3.1)	Monthly	1 to 2 years
		Foam concentrate solidification or buildup	Proportioning system insp. (Section 8-2.11.3.1)	Monthly	1 to 2 years
Fails to open	PL	Foam concentrate solidification or buildup	Proportioning system insp. (Section 8-2.11.3.1)	Monthly	1 to 2 years

Foam and Foam-water Systems [Nozzles (NFPA 11 and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Plugged	PL	Pipe scale	Full flow test (Section 8-3.3.3)	Annually	Not required
		Debris	Full flow test (Section 8-3.3.3)	Annually	Not required
		Improper replacement of a nozzle (e.g., piping tape covering the orifice)	Full flow test (Section 8-3.3.3)	Annually	Not required
		Foam concentrate buildup	Full flow test (Section 8-3.3.3)	Annually	Not required

Foam and Foam-water Systems [Monitors (NFPA 11)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture of monitor body	TL	Mechanical damage	Discharge device inspection (Section 8-2.5)	Monthly	Semiannually
		Corrosion	Discharge device inspection (Section 8-2.5)	Monthly	Semiannually
Monitor body plugged/blocked	TL	Strainer failure resulting in debris buildup or pipe scale	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Monitor fails to oscillate	PM	Mechanical obstruction in rotating components	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Inadequate lubrication of the rotating components	Full flow test (Section 8-3.3)	Annually	1 to 2 years
		Failure of mechanical transmission mechanism	Full flow test (Section 8-3.3)	Annually	1 to 2 years
Air inlet plugged	PL	Buildup of external debris (e.g., bugs) on the air inlet screen	Discharge device inspection (Section 8-2.5)	Monthly	1 to 2 years
		Buildup or solidification of foam concentrate due to improper flushing after foam discharge	Full flow test (Section 8-3.3) Proper flushing after actuation	Annually As necessary	Not required As necessary

Foam and Foam-water Systems [Low Expansion Foam Maker (NFPA 11, 11A and 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Inspection (NFPA 11, Section 7-1)	Annually	1 to 2 years
Body plugged/blocked	TV	Buildup of external debris (e.g., bird nest)	Inspection (NFPA 11, Section 7-1)	Annually	Not required
Air inlet plugged/blocked	PL	Buildup of external debris (e.g., bird nest)	Inspection (NFPA 11, Section 7-1)	Annually	Not required
		Foam-water solution buildup and solidification due to improper flushing after discharge	Inspection (NFPA 11, Section 7-1) Proper flushing after discharge	Annually As necessary	Not required As necessary

Foam and Foam-water Systems [Hi-expansion Aspirator Type Foam Generator (NFPA 11A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture of the turbulence chamber	PL	Mechanical damage	Inspection (Section A-1-13.1.4)	Weekly	1 to 2 years
Foam water solution inlet blocked	PL	Foam concentrate buildup and solidification	Operating inspection (Section 1-13.1)	Annually	Not required
		Foam-water line strainer failure resulting in a debris buildup	Operating inspection (Section 1-13.1)	Annually	Not required
Outlet screen plugged/blocked	PL	Foam concentrate buildup and solidification	Inspection (Section A-1-13.1.4) Proper flushing after actuation	Weekly As necessary	Semiannually As necessary
Outlet screen ruptured (e.g., damaged, ripped)	PL	Mechanical damage	Inspection (Section A-1-13.1.4)	Weekly	1 to 2 years

Foam and Foam-water Systems [Hi-expansion Blower Type Foam Generator (NFPA 11A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Foam-water nozzle/line external leak/rupture	PL	Mechanical damage	Inspection (Section A-1-13.1.4)	Weekly	1 to 2 years
Foam-water nozzle/line plugged/blocked	PL	Foam concentrate buildup and solidification	Operating inspection (Section 1-13.1)	Annually	Not required
		Foam-water line strainer failure resulting in debris buildup	Operating inspection (Section 1-13.1)	Annually	Not required
Fan fails to start or fails off while running	PL	Loss of electricity	Operating inspection (Section 1-13.1)	Annually	Not required
		Jamming of the fan blade	Operating inspection (Section 1-13.1)	Annually	Not required
		Electric motor failure	Operating inspection (Section 1-13.1)	Annually	Not required
		Mechanical damage	Inspection (Section A-1-13.1.4)	Weekly	1 to 2 years
		Rotating fan component seizure	Operating inspection (Section 1-13.1)	Annually	Not required
Fan operates at degraded flow performance	PL	Bent blades	Inspection (Section A-1-13.1.4)	Weekly	1 to 2 years
Outlet screen plugged/blocked	PL	Foam concentrate buildup and solidification	Inspection (Section A-1-13.1.4) Proper flushing after actuation	Weekly As necessary	1 to 2 years As necessary
Outlet screen ruptured (e.g., damaged, ripped)	PL	Mechanical damage	Inspection (Section A-1-13.1.4)	Weekly	1 to 2 years

Dry-pipe Sprinkler Systems [Differential and Lo-differential DPV (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	External DPV inspection (Section 9-4.4.1.3) Low air pressure alarm response Waterflow alarm response	Monthly As necessary As necessary	1 to 2 years As necessary As necessary
		Erosion/corrosion	External DPV inspection (Section 9-4.4.1.3) Low air pressure alarm response Waterflow alarm response	Monthly As necessary As necessary	1 to 2 years As necessary As necessary
		Freezing	Valve enclosure heating equipment inspection (Section 9-4.4.1.1) External DPV inspection (Section 9-4.4.1.3) Low air pressure alarm response Low temperature alarm response Waterflow alarm response	Daily/weekly Monthly As necessary As necessary As necessary	1 to 2 years 1 to 2 years As necessary As necessary As necessary
Internal leak	TL	Corrosion of the dry pipe valve (DPV) seat	Internal DPV inspection (Section 9-4.4.1.4)	Annually	1 to 2 years
		Loss of air pressure downstream of the DPV	Internal DPV inspection (Section 9-4.4.1.4) Low air pressure alarm response	Annually As necessary	1 to 2 years As necessary
		Low priming water level	Internal DPV inspection (Section 9-4.4.1.4) Priming water level test (Section 9-4.4.2.1)	Annually Quarterly	1 to 2 years 1 to 2 years
Fails to open	TV	Debris on valve	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Sticking of the DPV because of seat material deterioration	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Sprinkler piping obstruction	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
Change position/spurious position after opening	PV	Debris in piping above the DPV	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Corrosion	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Broken lever spring	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
Opens prematurely	TV	Loss of air pressure in a sprinkler line	Low air pressure alarm response Waterflow alarm response	As necessary As necessary	As necessary As necessary
		High pressure in the fire water supply line	Waterflow alarm response	As necessary	As necessary

Dry-pipe Sprinkler Systems [Mechanical DPV (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	External DPV inspection (Section 9-4.4.1.3) Low air pressure alarm response Waterflow alarm response	Monthly As necessary As necessary	1 to 2 years As necessary As necessary
		Erosion/corrosion	External DPV inspection (Section 9-4.4.1.3) Low air pressure alarm response Waterflow alarm response	Monthly As necessary As necessary	1 to 2 years As necessary As necessary
		Freezing	Valve enclosure heating equipment inspection (Section 9-4.4.1.1) External DPV inspection (Section 9-4.4.1.3) Low air pressure alarm response Waterflow alarm response Low temperature alarm response	Daily/weekly Monthly As necessary As necessary As necessary	1 to 2 years 1 to 2 years As necessary As necessary As necessary
Internal leak	TL	Corrosion of the DPV seat	Internal DPV inspection (Section 9-4.4.1.4)	Annually	1 to 2 years
		Loss of air pressure downstream of the DPV	Internal DPV inspection (Section 9-4.4.1.4) Low air pressure alarm response	Annually As necessary	1 to 2 years As necessary
		Low priming water level	Internal DPV inspection (Section 9-4.4.1.4) Priming water level test (Section 9-4.4.2.1)	Annually Quarterly	1 to 2 years 1 to 2 years
Fails to open	TV	Debris on top of the DPV	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Sticking of the DPV seat because of seat material deterioration	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Sprinkler piping obstruction	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Corrosion of mechanical linkage and pivot pin	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
Change position/spurious position after opening	PV	Debris in piping above the DPV	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
		Corrosion	Dry-pipe trip test (Section 9-4.4.2.2)	Annually	Not required
Opens prematurely	TV	Loss of air pressure in a sprinkler line	Low air pressure alarm response Waterflow alarm response	As necessary As necessary	As necessary As necessary
		High pressure in the fire water supply line	Waterflow alarm response	As necessary	As necessary

Dry-pipe Sprinkler Systems [Air Supply (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Deterioration of piping and hose connections	Low air pressure alarm response	As necessary	As necessary
		Gasket deterioration	Low air pressure alarm response	As necessary	As necessary
Fails with no air supply	ML	Compressor fails to start	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Air supply isolation valve closed	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Pressure regulator/piping plugged	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Pressure regulator fails	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
Improper supply characteristics: low pressure	ML	Improper pressure regulator setting	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Pressure relief valve leaking	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		High priming water level	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Low air pressure alarm response Priming water level test (Section 9-4.4.2.1)	Weekly/monthly As necessary Quarterly	Not required As necessary Not required

Dry-pipe Sprinkler Systems [Alarm Circuit Trim (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture of alarm circuit piping, waterflow alarm check valves, alarm test or shutoff valve	PV	Corrosion	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Dry pipe system trip test (Section 9-4.4.2.2)	Weekly/monthly Annually	Not required Not required
		Freezing	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Dry pipe system trip test (Section 9-4.4.2.2)	Weekly/monthly Annually	Not required Not required
		Mechanical damage	Gauge inspection (Sections 2-2.4.2 & 9-4.4.1.2) Dry pipe system trip test (Section 9-4.4.2.2)	Weekly/monthly Annually	Not required Not required
Alarm circuit piping plugged	PM	Debris	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	1 to 2 years
		Stuck check valve (e.g., corrosion)	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	1 to 2 years
		Improper positioning of manual valves	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	1 to 2 years
Alarm circuit strainer plugged	PL	Debris	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
Internal leak in the alarm test or shutoff valve	PV	Debris	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
		Valve seat degraded	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
Alarm line isolation valve plugged	PL	Debris	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
Alarm line isolation valve left closed	PM	Human error	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	1 to 2 years
Check valve fails to close on demand	PL	Corrosion	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
		Debris	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required

Dry-pipe Sprinkler Systems [Test Valve and Piping (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture of the piping or test valve	PL	Corrosion	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
		Freezing	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required
		Mechanical damage	Dry pipe system trip test (Section 9-4.4.2.2)	Annually	Not required

Dry-pipe Sprinkler Systems [Drain Valve and Piping (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture in drain valves or piping	PL	Corrosion	Main drain test (Section 9-2.6)	Quarterly	Not required
		Freezing	Main drain test (Section 9-2.6)	Quarterly	Not required
		Mechanical damage	Main drain test (Section 9-2.6)	Quarterly	Not required
Drain valve/piping plugged	TL	Debris	Main drain test (Section 9-2.6)	Quarterly	1 to 2 years
		Corrosion	Main drain test (Section 9-2.6)	Quarterly	1 to 2 years

Deluge, Water Spray and Pre-action Systems [Valve (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	External valve inspection (Section 9-4.3.1.2) Low air pressure response Waterflow alarm response	Monthly As necessary As necessary	1 to 2 years As necessary As necessary
		Erosion/corrosion	External valve inspection (Section 9-4.3.1.2) Low air pressure response Waterflow alarm response	Monthly As necessary As necessary	1 to 2 years As necessary As necessary
		Freezing	Valve enclosure heating equipment inspection (Section 9-4.3.1) External valve inspection (Section 9-4.3.1.2) Low air pressure response Low temperature alarm response Waterflow alarm response	Daily/weekly Monthly As necessary As necessary As necessary	1 to 2 years 1 to 2 years As necessary As necessary As necessary
Internal leak	TV	Corrosion of the valve seat	Internal valve inspection (Section 9-4.3.1.3)	Annually	Not required
Fails to open	TL	Debris on top of the valve	Internal valve inspection (Section 9-4.3.1.3) Full system trip test (Section 9-4.3.2.2)	Annually Annually	1 to 2 years 1 to 2 years
		Valve seat sticks because of seat material deterioration	Internal valve inspection (Section 9-4.3.1.3) Full system trip test (Section 9-4.3.2.2)	Annually Annually	1 to 2 years 1 to 2 years
		Failure to receive output signal from the detection system to actuate valve	Internal valve inspection (Section 9-4.3.1.3) Full system trip test (Section 9-4.3.2.2)	Annually Annually	1 to 2 years 1 to 2 years
		Failure of the valve actuator to operate	Internal valve inspection (Section 9-4.3.1.3) Full system trip test (Section 9-4.3.2.2)	Annually Annually	1 to 2 years 1 to 2 years
Change in position/spurious position after opening	PV	Debris in the piping downstream the valve	Full system trip test (Section 9-4.3.2.2)	Annually	Not required
		Corrosion	Internal valve inspection (Section 9-4.3.1.3) Full system trip test (Section 9-4.3.2.2)	Annually Annually	Not required Not required
		Broken clapper latch	Internal valve inspection (Section 9-4.3.1.3) Full system trip test (Section 9-4.3.2.2)	Annually Annually	Not required Not required

Deluge, Water Spray and Pre-action Systems [Weighted Release Mechanisms (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to change position (i.e., weight does not drop)	TL	Bent/misaligned/corroded guide	Full system trip test (Section 9-4.3.2.2)	Annually	1 to 2 years
		Release pin sticks/fails to retrack	Full system trip test (Section 9-4.3.2.2)	Annually	1 to 2 years
		Weight physically blocked in the unactuated position (i.e., failure to remove the device used to hold the weight up when resetting the valve)	Full system trip test (Section 9-4.3.2.2)	Annually	1 to 2 years

Deluge, Water Spray and Pre-action Systems [Diaphragm Release Mechanisms (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Diaphragm case external leak/rupture	MV	Mechanical damage	Waterflow alarm response	As necessary	As necessary
		Corrosion	Waterflow alarm response	As necessary	As necessary
		Erosion	Waterflow alarm response	As necessary	As necessary
Leak/rupture of diaphragm (with a spring assembly)	ML	Debris that punctures the diaphragm	Waterflow alarm response	As necessary	As necessary
		Diaphragm embrittlement	Waterflow alarm response	As necessary	As necessary
Leak/rupture of diaphragm (w/o a spring assembly)	TV	Debris that punctures the diaphragm	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	5 years Not required
		Diaphragm embrittlement	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	5 years Not required

Diaphragm case outlet plugged/blocked	TL	Freezing	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	5 years 1 to 2 years
		Microbiological induced corrosion (MIC)	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	5 years 1 to 2 years
		Mussel shells in the raw water supply	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	5 years 1 to 2 years
		Debris	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	5 years 1 to 2 years
Diaphragm (with a spring assembly) fails to open	TV	Failure of the spring assembly (e.g., broken spring)	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	Not required Not required
Diaphragm fails to change position/spurious operation	TV	Physical obstruction (e.g., debris, shells) behind diaphragm	Internal component inspection (Sec. 9-4.3.1.4) Full system trip test (Section 9-4.3.2.2)	5 years Annually	Not required Not required
Diaphragm opens prematurely	MV	Diaphragm leak/rupture	Waterflow alarm response	As necessary	As necessary

Deluge, Water Spray and Pre-action Systems [Mercury Check Release Mechanisms (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TV	Mechanical damage	External valve inspection (Sec. 9-4.3.1.2)	Monthly	1 to 2 years

Deluge, Water Spray and Pre-action Systems [Air Supply System (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	MM	Piping and/or hose connection deterioration	Low air pressure alarm response	As necessary	As necessary
		Gasket deterioration	Low air pressure alarm response	As necessary	As necessary
Fails with no supply from the system	ML	Air restriction valve plugged	Low air pressure alarm response	As necessary	As necessary
		Compressor start failure	Low air pressure alarm response	As necessary	As necessary
		Closed valve	Low air pressure alarm response	As necessary	As necessary
		Pressure regulator/piping plugged	Low air pressure alarm response	As necessary	As necessary
		Pressure regulator failure	Low air pressure alarm response	As necessary	As necessary
Improper supply characteristics: low pressure	ML	Improper regulator setting	Low air pressure alarm response	As necessary	As necessary
		Pressure relief valve leakage	Low air pressure alarm response	As necessary	As necessary

Deluge, Water Spray and Pre-action Systems [Release Solenoid (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	MV	Mechanical damage	Waterflow alarm response	As necessary	As necessary
Internal leak	MV	Solenoid valve seat erosion/corrosion	Waterflow alarm response	As necessary	As necessary
Plugged	TV	Debris	Full system trip test (Section 9-4.3.2.2)	Annually	Not required
		Corrosion	Full system trip test (Section 9-4.3.2.2)	Annually	Not required
		MIC	Full system trip test (Section 9-4.3.2.2)	Annually	Not required
Fails to open (NC solenoid valve)	TL	Loss of signal	Full system trip test (Section 9-4.3.2.2)	Annually	1 to 2 years
Opens prematurely	ML	Power loss (for a NC solenoid valve)	Waterflow alarm response	As necessary	As necessary
		Solenoid valve coil failure (for a NO solenoid valve)	Waterflow alarm response	As necessary	As necessary

Deluge, Water Spray and Pre-action Systems [Manual Pull (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	ML	Mechanical damage	Waterflow alarm response	As necessary	As necessary
		Manual pull valve seat deterioration	Waterflow alarm response	As necessary	As necessary
Fails to open	TV	Corrosion	Manual actuation operation (Section 9-4.3.2.6)	Annually	Not required
		Missing/broken handle	Manual actuation operation (Section 9-4.3.2.6)	Annually	Not required
		Separation of manual pull valve stem and disk/ball	Manual actuation operation (Section 9-4.3.2.6)	Annually	Not required

Plugged	TV	Debris	Manual actuation operation (Section 9-4.3.2.6)	Annually	Not required
		MIC	Manual actuation operation (Section 9-4.3.2.6)	Annually	Not required
		Corrosion	Manual actuation operation (Section 9-4.3.2.6)	Annually	Not required

Deluge, Water Spray and Pre-action Systems [Alarm Circuit Trim (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PV	Corrosion	External component inspection (Sec. 9-4.3.1.2)	Monthly	Not required
		Freezing	External component inspection (Sec. 9-4.3.1.2)	Monthly	Not required
		Mechanical damage	External component inspection (Sec. 9-4.3.1.2)	Monthly	Not required
Piping plugged/blocked	PV	Corrosion	Full system trip test (Section 9-4.3.2.2)	Annually	Not required
		Debris	Full system trip test (Section 9-4.3.2.2)	Annually	Not required
		MIC	Full system trip test (Section 9-4.3.2.2)	Annually	Not required

Deluge, Water Spray and Pre-action Systems [Drain Valves (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture in drain valves or piping	PL	Corrosion	Main drain test (Section 9-2.6)	Quarterly	Not required
		Freezing	Main drain test (Section 9-2.6)	Quarterly	Not required
		Mechanical damage	Main drain test (Section 9-2.6)	Quarterly	Not required

Drain valve or piping plugged	TL	Corrosion	Main drain test (Section 9-2.6) Full system trip test (Section 9-4.3.2.2)	Quarterly Annually	1 to 2 years 1 to 2 years
		MIC	Main drain test (Section 9-2.6) Full system trip test (Section 9-4.3.2.2)	Quarterly Annually	1 to 2 years 1 to 2 years
		Debris	Main drain test (Section 9-2.6) Full system trip test (Section 9-4.3.2.2)	Quarterly Annually	1 to 2 years 1 to 2 years

Deluge, Water Spray and Pre-action Systems [Deluge and Water Spray Nozzles (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Plugged	PL	Pipe scale	Discharge pattern observations during full system trip test (Section 9-4.3.2.2)	Annually	Not required
		Debris	Discharge pattern observations during full system trip test (Section 9-4.3.2.2)	Annually	Not required
		Improper replacement of a nozzle (e.g., piping tape covering the orifice)	Discharge pattern observations during full system trip test (Section 9-4.3.2.2)	Annually	Not required
Misdirected	PL	Mechanical damage	Discharge pattern observations during full system trip test (Section 9-4.3.2.2)	Annually	Not required
		Human error	Discharge pattern observations during full system trip test (Section 9-4.3.2.2)	Annually	Not required

Deluge, Water Spray and Pre-action Systems [Air Supply (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Deterioration of piping and hose connections	Low air pressure alarm response	As necessary	As necessary
		Gasket deterioration	Low air pressure alarm response	As necessary	As necessary
Fails with no air supply	ML	Compressor fails to start	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Air supply isolation valve closed	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Pressure regulator/piping plugged	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Pressure regulator fails	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
Improper supply characteristics: low pressure	ML	Improper pressure regulator setting	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		Pressure relief valve leaking	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response	Weekly/monthly As necessary	Not required As necessary
		High priming water level	Gauge inspection (Sections 2-2.4.2 & 9-4.3.1.1) Low air pressure alarm response Priming water level test (Section 9-4.3.2.1)	Weekly/monthly As necessary Quarterly	Not required As necessary Not required

Standpipe and Hose Systems [Hose (NFPA 25 &1962)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TM (rips and rotting) TL (other)	Rips/tears from use	Hose inspection (NFPA 1962, Section 2-3.3)	Annually*	Semiannually*
		Hose lining deterioration	Hose inspection (NFPA 1962, Section 2-3.3) Hose test (NFPA 1962, Section 2-3.2)	Annually* 5 years/3 years	1 to 2 years* 5 years/3 years
		Hose rotting due to storing it wet	Hose inspection (NFPA 1962, Section 2-3.3) Hose test (NFPA 1962, Section 2-3.2)	Annually* 5 years/3 years	Semiannually* 5 years/3 years
		Hose gasket deterioration	Hose inspection (NFPA 1962, Section 2-3.3)	Annually*	1 to 2 years*
		Coupling leaks	Coupling inspection (NFPA 1962, Section 4-2.1)	Annually*	1 to 2 years*
		PRV fails with a high pressure output	Hose connection/PRV flow test (NFPA 25, Sections 9-5.2.2 and .3.2)	5 years	5 years
Plugged/blocked	PL	Debris buildup	Hose inspection (NFPA 1962, Section 2-3.3)	Annually*	Not required

* Also after each use

Standpipe and Hose Systems [Pressure Regulating Hose Valves/Connections (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	PL	Mechanical damage	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Not required
		Valve packing leakage	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Not required
		Thread damage due to cross-threading	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Not required
Plugged/blocked	PH	Debris buildup	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Semiannually
		Purposeful placing of trash in outlet	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Semiannually

Fails with no/low outlet pressure	PM	Pilot tube pluggage	PRV flow test (Sections 9-5.2.2 & .3.2)	5 years	5 years
		Improper adjustment	PRV flow test (Sections 9-5.2.2 & .3.2)	5 years	5 years
		Jamming/sticking of valve internals (e.g., valve seat or stem)	PRV flow test (Sections 9-5.2.2 & .3.2)	5 years	5 years
Fails with a high output pressure	PM	Improper adjustment	PRV flow test (Sections 9-5.2.2 & .3.2)	5 years	5 years
		Broken regulating spring	PRV flow test (Sections 9-5.2.2 & .3.2)	5 years	5 years
		Pilot tube pluggage	PRV flow test (Sections 9-5.2.2 & .3.2)	5 years	5 years
Fails to open	PM	Broken hand wheel	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	1 to 2 years
		Jamming/sticking of valve internals (e.g., valve seat or stem)	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	1 to 2 years
		Improper adjustment not allowing the valve to open	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	1 to 2 years
Damaged threads	PL	Mechanical damage	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Not required
		Thread damage due to cross-threading when reinstalling the cap or connecting a hose	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Not required
		Corrosion	Hose connection/PRV inspection (Sections 9-5.2.1 & .3.1)	Quarterly	Not required

Standpipe and Hose Systems [Hose Nozzle (NFPA 1962)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Nozzle inspection (Section 4-1.2)	Annually*	1 to 2 years
		Nozzle gasket damage or deterioration	Nozzle inspection (Section 4-1.2)	Annually*	1 to 2 years
Plugged	TL	Debris buildup	Nozzle inspection (Section 4-1.2)	Annually*	1 to 2 years
		Hose lining deterioration	Nozzle inspection (Section 4-1.2)	Annually*	1 to 2 years
Fails to fully open	TL	Breaking of valve hand/stem linkage	Nozzle inspection (Section 4-1.2)	Annually*	1 to 2 years
		Jamming/sticking of the valve ball	Nozzle inspection (Section 4-1.2)	Annually*	1 to 2 years
Inability to change nozzle spray pattern	ML	Jamming/sticking of the nozzle spray cone	Nozzle inspection (Section 4-1.2)	Annually*	Not required

* and after each use

Standpipe and Hose Systems [Hose Storage Device (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to allow hose extension	PL	Jamming/sticking of the rack pins	Hose storage device inspection (Section 3-2.3)	Annually	Not required
		Inability to swing the rack out of the hose cabinet	Hose storage device inspection (Section 3-2.3)	Annually	Not required
		Jamming/sticking of the hose reel rotating components	Hose storage device inspection (Section 3-2.3)	Annually	Not required
		Jamming/sticking of the hose cabinet door	Hose storage cabinet inspection (Section 3-2.3)	Annually	Not required

Standpipe and Hose Systems [Piping (NFPA 25)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak/rupture	TL	Mechanical damage	Piping inspection (Section 3-2.1) Hydrostatic test (Section 3-3.2.1)	Quarterly 5 years	1 to 2 years 5 years
		Corrosion	Piping inspection (Section 3-2.1) Hydrostatic test (Section 3-3.2.1)	Quarterly 5 years	1 to 2 years 5 years
		Freezing	Piping inspection (Section 3-2.1)	Quarterly	1 to 2 years
Plugged/blocked	PL	Debris buildup	Standpipe flow test (Section 3-3.1.1)	5 years	5 years
		Pipe scale accumulation	Standpipe flow test (Section 3-3.1.1)	5 years	5 years
		Freezing	Standpipe flow test (Section 3-3.1.1)	5 years	5 years

Wet/Dry Chemical Systems [Piping (NFPA 17 and 17A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External rupture	TL	Mechanical damage	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	Semiannually Semiannually
		Corrosion	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	Semiannually Semiannually
External leak	PM	Mechanical damage	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Corrosion	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
Plugged/blocked	TM	Caking of extinguishing agent	Dry chemical system maintenance (Sec. 9-3.1)	Semiannually	Semiannually

Wet/Dry Chemical Systems [Nozzles (NFPA 17 and 17A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Plugged/blocked	PM	Caking of extinguishing agents	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Covering of nozzle (e.g., leaving tape/plastic bags on nozzles after painting)	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Missing blowoff caps allowing foreign material buildup (e.g., grease)	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
Misdirected	PL	Mechanical damage	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	Not required Not required

Wet/Dry Chemical Systems [Dry Chemical Pressurized Storage Cylinder (NFPA 17)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak	TL	Leaking of the valve packing	Dry chemical system maintenance (Sec 9-3.1)	Semiannually	1 to 2 years
		Leaking at the threaded connection for the operating device	Dry chemical system maintenance (Sec 9-3.1)	Semiannually	1 to 2 years
		Cylinder corrosion	Dry chemical system maintenance (Sec 9-3.1)	Semiannually	1 to 2 years
External rupture	TL	Mechanical damage	Dry chemical system inspection (Section 9-2.1)	Monthly	Semiannually
		Cylinder corrosion	Dry chemical system inspection (Section 9-2.1)	Monthly	Semiannually
Cylinder outlet plugged/blocked	TL	Dry chemical caking	Dry chemical system maintenance (Sec 9-3.1)	Semiannually	1 to 2 years

Wet/Dry Chemical Systems [Fusible Links (NFPA 17 and 17A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Fails to melt at correct temperature	TL	Coating of the link with foreign material (e.g., grease, paint)	Wet chemical system maintenance (Sec. 5-3.1) Wet chemical link replacement (Section 5-3.2) Dry chemical system maintenance (Sec. 9-3.1) Dry chemical link replacement (Section 9-3.2)	Semiannually Annual Semiannually Annual	1 to 2 years 1 to 2 years 1 to 2 years 1 to 2 years
Opens prematurely	ML	Mechanical damage	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	Not required Not required
		Replacement of wrong temperature link	Wet chemical system maintenance (Sec. 5-3.1) Wet chemical link replacement (Section 5-3.2) Dry chemical system maintenance (Sec. 9-3.1) Dry chemical link replacement (Section 9-3.2)	Semiannually Annual Semiannually Annual	Not required Not required Not required Not required

Wet/Dry Chemical Systems [Non-Pressurized Extinguishing Agent Storage Cylinder w/ Expellant Cylinder (NFPA 17 and 17A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
External leak	PL	Leaking of the valve packing	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	Not required Not required
		Leaking at the threaded connection for the operating device	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	Not required Not required
		Cylinder corrosion	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	Not required Not required
External rupture	TV	Mechanical damage	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	1 to 2 years 1 to 2 years
		Cylinder corrosion	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	1 to 2 years 1 to 2 years
Cylinder outlet plugged	TL	Extinguishing agent caking	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years

Wet/Dry Chemical Systems [Actuation Device (NFPA 17 and 17A)]

Failure Mode	FMEA Ranking	Failure Cause	ITM Task	Task Frequency	
				NFPA	Recomm'd
Plugged/blocked	TL	Extinguishing agent caking	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Separation of the operating device internals from the release mechanism	Wet chemical system maintenance (Sec. 5-3.1) Dry chemical system maintenance (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
Fails to open	TL	Obstruction in fusible link or manual pull station cable conduit	Wet chem activation w/o discharge (Sec. 5-3.1) Dry chem activation w/o discharge (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Tensioning spring failure	Wet chem activation w/o discharge (Sec. 5-3.1) Dry chem activation w/o discharge (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Jamming/sticking of the valve	Wet chem activation w/o discharge (Sec. 5-3.1) Dry chem activation w/o discharge (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
		Jamming/sticking of the releasing latch	Wet chem activation w/o discharge (Sec. 5-3.1) Dry chem activation w/o discharge (Sec. 9-3.1)	Semiannually Semiannually	1 to 2 years 1 to 2 years
Opens prematurely	ML	Cable failure	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	1 to 2 years 1 to 2 years
		Fusible link failure	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	1 to 2 years 1 to 2 years
		Inadvertent manual actuation	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	1 to 2 years 1 to 2 years
		Releasing latch failure	Wet chemical system inspection (Section 5-2.1) Dry chemical system inspection (Section 9-2.1)	Monthly Monthly	1 to 2 years 1 to 2 years

APPENDIX B

Derivation of Mathematical Model for ITM Task Frequency Assessment

APPENDIX B

Derivation of Mathematical Model for ITM Task Frequency Assessment

B.1 PURPOSE

This appendix provides a detailed explanation of the mathematical model referenced in Section 3.3.5. This model was developed to allow the team to determine the frequency with which ITM tasks need to be performed to achieve system and component reliability targets.

B.1.1 Mathematical Model Development

The development of this model involved six steps:

Step 1 – Development of an event tree model

Step 2 – Derivation of the mathematical expression for the event tree

Step 3 – Prediction of failure rates for component failure modes

Step 4 – Development of a scoring approach

Step 5 – Development of recommended frequency tables

Step 6 – Comparison of predicted failure rates to published failure data for selected components

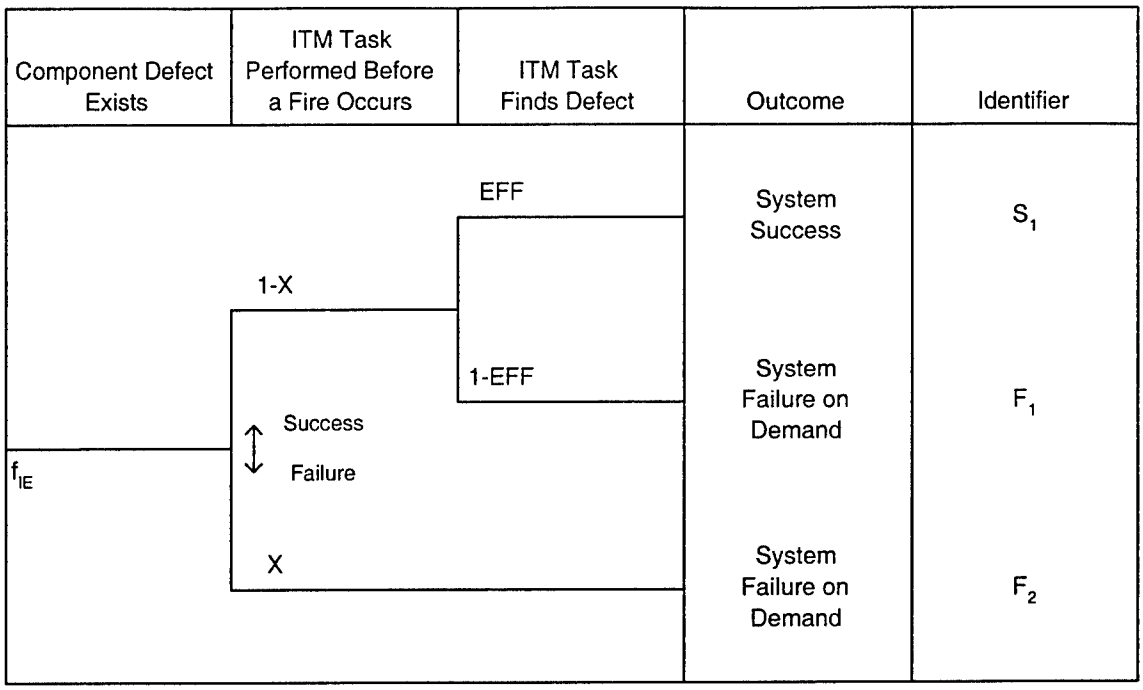
B.1.1.1 Development of an Event Tree Model

An event tree model was developed to represent the different scenarios that result in a fire protection system not operating correctly because of a component failure. This model includes the failure rate for component failure modes that prevent the fire suppression from functioning, the probability of the ITM task being performed before a fire occurs, and the probability that the ITM task detects the defect and it is corrected. The event tree model is provided in Figure B.1. The mathematical symbols used in the event tree are provided in Table B.1.

B.1.1.2 Derivation of the Mathematical Expression for the Event Tree

The event tree was used to develop a mathematical model that represents the frequency with which a system (i.e., fire protection system) will fail when there is a demand (i.e., fire) for specific failure mode. The frequency with which the system will fail when there is demand is obtained by adding F_1 and F_2 (as defined in Figure B.1). This results in the following equation:

$$F_{system} = F_1 + F_2 = f_{ie}\,(1\text{-}x)(1\text{-}EFF) + f_{ie}\,(x) \qquad (1)$$



e:\data\jbfa-rpt\1997\lr29697\figure b-

Figure B.1 Event Tree Model

Table B.1 Mathematical Symbols in the Event Tree

Event Tree Branch	Mathematical Symbol	Description
Component Defect Exists	f_{ie}	Failure rate for component failure mode
ITM Task Performed Before a Fire Occurs	1-x	Probability that a fire does not occur before an ITM task (that should detect the defect) is performed
ITM Task Finds Defect	EFF	Probability that the ITM task will indeed detect and correct the defect, given that the ITM task is performed
Outcome - System Success	S_1	Frequency of the system operating successfully
Outcome - System Failure on Demand	F_1 and F_2	Frequency of the system failing on demand

The probability a fire occurring before an ITM task is performed was modeled assuming constant frequency of fires. The following equation was used to model this probability:

$$x=1-e^{-f_{Fire}(\frac{T}{2})} \quad (2)$$

where,

f_{Fire} = frequency of fires
I = interval of system testing

Substituting equation 2 into equation 1 gives the following equation:

$$F_{system} = F_1 + F_2 = f_{ie}[1 - \text{HF} * e^{-f_{Fire}(\frac{T}{2})}] \quad (3)$$

This frequency of the system failing when there is a demand was used to determine the frequency for ITM tasks required to achieve a targeted performance for fire protection systems. The targeted performances are defined in terms of availability. Table B.2 lists the targeted overall system availability and targeted individual component availability for the various system degradation levels. The individual component availabilities were arrived at by determining the average performance required for each component to achieve the targeted overall availability for the system assuming there are 10 components in a system.

Table B.2 Targeted Overall System and Individual Component Availabilities for System Degradation Levels

System Degradation Level	Targeted Overall System Availability	Targeted Individual Component Availability
Total	0.99	0.999
Partial	0.9	0.99
Minimal	0.5	0.95

It was then assumed that a component unavailability (1- availability) can be approximated by the unreliability equation to calculate the ITM task frequency. This assumption is valid since the ITM tasks are condition-monitoring tasks rather than rebuilding or refurbishing-type tasks. Given this assumption to be valid, then the following equation is valid:

$$(1\text{- availability}) \approx \overline{R} = 1 - e^{-F_{system}T} \quad (4)$$

where,

$\overline{R}$ = unreliability of the component

Substituting equation 3 into equation 4 gives the following equation:

$$\overline{R} = 1 - e^{-(f_{ie}[1-EFF * e^{-f_{Fire}(\frac{T}{2})}])T} \quad (5)$$

Rearranging the equation gives the following equation:

$$-\ln(1-\overline{R}) = f_{ie}\,[1-EFF * e^{-f_{Fire}(\frac{T}{2})}]T \quad (6)$$

The equation can be simplified by defining variables for certain expressions in the equation.

$$y = f_{ie} * z \quad (7)$$

where,

$$y = -\ln(1-\overline{R})$$

$$z = [1-EFF * e^{-f_{Fire}(\frac{T}{2})}]T$$

If values for fire frequency (f_{Fire}) and ITM task effectiveness (EFF) are fixed, equation 7 can be used to determine the ITM task frequency (I) required to achieve a targeted availability for the component if the failure rate of a component (f_{ie}) can be predicted.

B.1.1.3 Prediction of Failure Rates for Component Failure Modes

Since there is limited data on failure rates for many of the components in the fire protection systems analyzed, a method of predicting the failure rate was developed. This method is based on using the PFOD ranking and NFPA recommended interval to estimate the failure rate for a specific component failure mode. The median value of the PFOD range for each PFOD ranking category (i.e., high, medium, low, very low) and the NFPA recommended intervals (i.e., weekly, monthly, quarterly, semiannually, annually) were used to predict the failure rate. These values were used in the following equation to calculate an estimated failure rate for each PFOD ranking and NFPA recommended interval combination:

$$PFOD = f_{ie} * \frac{T}{2}$$

The results of these calculations are summarized in Table B.3.

Table B.3 Estimated Failure Rate for Component Failure Modes

PFOD Ranking	NFPA Recommended Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
High	10.4 failures/year	2.4 failures/year	0.8 failures/year	0.4 failures/year	0.2 failures/year
Medium	0.52 failures/year	0.12 failures/year	0.04 failures/year	0.02 failures/year	0.01 failures/year
Low	0.052 failures/year	0.012 failures/year	0.004 failures/year	0.002 failures/year	0.001 failures/year
Very Low	0.0052 failures/year	0.0012 failures/year	0.0004 failures/year	0.0002 failures/year	0.0001 failures/year

The estimated failure rate for a component failure mode is determined by the intersection of the PFOD ranking for the failure mode and NFPA recommended interval for the ITM task that was judged to be the most effective in detecting and/or preventing the failure mode from occurring.

B.1.1.4 Development of a Scoring Approach

A scoring approach was developed to account for lack of precision used in determining the failure rates for component failure modes. Since the PFOD rankings are based on order of magnitude estimates, a scoring approach based on order of magnitude was developed. Equation 7 can then be converted to the following simple expression:

$$Y = F - Z \tag{8}$$

where,

Y = score for y
F = score for f_{ie}
Z = order of magnitude reduction attributed to the ITM test interval and task effectiveness

The Z term represents the improvement in system performance that is attributed to the ITM task frequency and effectiveness. Therefore, for a one order of magnitude improvement (i.e., z = 0.1), Z will equal 1; for two orders of magnitude, Z will equal 2; and so on.

Table B.4 lists the scoring categories used for Y and F.

Table B.4 Scoring Categories

Score	Range of Values [1, 2]
6	1 to 10
5	0.1 to 1
4	0.01 to 0.1
3	0.001 to 0.01
2	0.0001 to 0.001
1	0.00001 to 0.0001

[1]To be conservative, calculated values for y that are approximately equal to a range limit are assigned the score of the lower range (e.g., y = 0.001 corresponds to a score of 2)
[2]To be conservative, calculated values for f_{ie} that are approximately equal to a range limit are assigned the score of the higher range (e.g., f_{ie} = 0.01 corresponds to a score of 4)

B.1.1.5 Development of Recommended Frequency Tables

The development of the recommended frequency tables involved the following steps:

Step 1 – Converting the failure rate data into scores

Step 2 – Calculating values for y for various component availabilities

Step 3 – Calculating the ITM test frequencies

Step 4 – Developing ITM recommended frequency tables

B.1.1.5.1 Converting the Failure Rate Data into Scores

Using the scoring categories in Table B.4, the failure rate data in Table B.3 was converted into scores. Table B.5 contains the failure rate data scores.

Table B.5 Failure Rate Data Scores

PFOD Ranking	NFPA Recommended Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
High	> 6 (i.e., > 10 failures/year)	6	5	5	5
Medium	5	5	4	4	4
Low	4	4	3	3	3
Very Low	3	3	2	2	2

B.1.1.5.2 Calculating Values for Y for Various Component Availabilities

Using the targeted component availabilities in Table B.2, values for y are calculated. These values are then converted into scores using Table B.4. Table B.6 contains the results of the calculation and the corresponding scores.

Table B.6 Targeted Individual Component Unavailabilities and Scores for System Degradation Levels

System Degradation Level	Targeted Individual Component Unavailability	y	Score
Total	0.001	0.001	2
Partial	0.01	0.01005	3
Minimal	0.05	0.0513	4

B.1.1.5.3 Calculating ITM Testing Frequency

The frequency for ITM tasks was determined by calculating the frequency required to achieve one, two, three, and four order of magnitude improvement in the system performance because of the test ITM task frequency (i.e., z equals 0.1, 0.01, 0.001, and 0.0001). Table B.7 summarizes the results for a fire frequency of 1/50 years and task effectiveness of 0.99.

Table B.7 Correlation of System Improvement to ITM Task Frequency

Targeted Amount of System Improvement (z)	Order of Magnitude of System Improvement (Z)	Calculated Task Frequency	Recommended Task Frequency
0.1	1	2.73 years	1 to 2 years
0.01	2	227 days	6 months
0.001	3	34 days	1 month
0.0001	4	4 days	1 week

B.1.1.5.4 Developing ITM Recommended Test Frequency Tables

The information in Tables B.5, B.6, and B.7 was combined to develop an ITM recommended frequency table for each level of system degradation. This was done by comparing the frequency score in each cell of Table B.5 to the score required for each system degradation level. For example, for total system degradation, each cell in Table B.5 was compared to a score of 2 (see Table B.6). If the score in a cell in Table B.5 was less than or equal to the score required for system degradation level, then no ITM task is required; however, if the score was greater than the score for the system degradation level, the score in the cell was subtracted from the score for the system degradation level to determine the level of system improvement required. Table B.7 was then used to determine the frequency for ITM tasks needed to achieve that level of improvement. For example, the failure rate score in Table B.5 for the cell corresponding to a PFOD ranking of high and a NFPA recommended interval of monthly is 6. For a failure mode that results a total system degradation, the failure rate score must be less than or equal to 2, or an ITM task is required. Since 4 order of magnitude improvement (i.e., the difference between 6 and 2) is required, Table B.7 recommends a frequency of 1 week for the ITM task. Section 3.3.5

provides recommended frequency tables for the three system degradation levels and common components servicing several systems.

B.1.1.6 Comparison of Predicted Failure Rates to Published Failure Data for Selected Components

To verify the validity of the methodology used to estimate the failure rate for component failure modes, a comparison of the predicted failure rate (see Table B.3) to published failure rate data was performed for selected components. Table B.8 summarizes this comparison.

Table B.8 Comparison of Predicted Failure Rate to Published Failure Rate for Selected Components

Component	Failure Mode	Published Failure Rate (Failures/Year)	Component PFOD Ranking Assigned	Failure Rate Range (Failures/Year)
Alarm check valve	Fails to open on demand	0.0018[1]	Very low	0.0001 to 0.0052
Sprinkler head	Fails to open on demand	0.0005[2]	Very Low	0.0001 to 0.0052
Solenoid valve	Composite failure rate	0.019[3]	Low	0.001 to 0.052
Pressure switch	Fails to detect a pressure drop	0.0035[3]	Low	0.001 to 0.052
Fire water supply	Loss of supply	0.01[4]	Medium	0.01 to 0.52
Smoke detector	Unknown	0.41[5,6]	Medium	0.01 to 0.52
Piping (1000 feet)	Rupture	0.044[7]	Medium	0.01 to 0.52

[1]NUREG/CR-2815.
[2]AIChE annual meeting paper No. 7B, 1982.
[3]IEEE-Std-500-1984.
[4]INPO 83-034, *Nuclear Plant Reliability Data Annual Report*, October 1983.
[5]Nonelectronic Parts Reliability Data, NPRD-95, Reliability Analysis Center, 1995.
[6]Failure Mode/Mechanism Distribution, FMD-97, Reliability Analysis Center, 1997.
[7]JBFA-101-89, *Reliability Analysis of Underground Fire Water Piping at the Paducah Gaseous Diffusion Plant*, January 1990.

APPENDIX C

References

APPENDIX C

References

Note: The following reference documents form a part of this handbook to the extent specified herein. Users of this handbook should refer to the latest revision of cited documents unless otherwise directed.

Non-Government Publications

Unless otherwise indicated, copies are available from the National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 11: Standard for Low-Expansion Foam, 1998 Edition

NFPA 11A: Standard for Medium-and High-Expansion Foam Systems, 1994 Edition

NFPA 12: Standard on Carbon Dioxide Extinguishing Systems, 1998 Edition

NFPA 12A: Standard on Halon 1301 Fire Extinguishing Systems, 1997 Edition

NFPA 13: Standard for the Installation of Sprinkler Systems, 1996 Edition

NFPA 14: Standard for the Installation of Standpipe and Hose Systems, 1996 Edition

NFPA 15: Standard for Water Spray Fixed Systems for Fire Protection, 1996 Edition

NFPA 16: Standard for the Installation of Deluge Foam-Water Sprinkler And Foam-Water Spray Systems, 1995 Edition

NFPA 16A: Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems, 1994 Edition

NFPA 17: Standard for Dry Chemical Extinguishing Systems, 1998 Edition

NFPA 17A: Standard for Wet Chemical Extinguishing Systems, 1998 Edition

NFPA 20: Standard for the Installation of Centrifugal Fire Pumps, 1996 Edition

NFPA 22: Standard for Water Tanks for Private Fire Protection, 1998

Edition

NFPA 25: Standard for the Inspection, Testing and Maintenance of Water Based Fire Protection Systems, 1998 Edition

NFPA 72: National Fire Alarm Code, 1996 Edition

NFPA 750: Standard on Water Mist Fire Protection Systems, 1996 Edition

NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems, 1996 Edition